PERCEPTION OF EMOTIONS IN MUSIC AND SPEECH IN PEOPLE WITH PARKINSON'S DISEASE (PD) AND HEALTHY AGE-MATCHED CONTROLS

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PERCEPTION OF EMOTIONS IN MUSIC AND SPEECH IN PEOPLE WITH PARKINSON'S DISEASE (PD) AND HEALTHY AGE-MATCHED CONTROLS

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Abstract: People with Parkinson's disease (PD) often present with emotional perception deficits. Prior studies provide support that these deficits are seen in the processing of verbal as well as non-verbal emotions. The current study compared the perception of emotions (e.g., happy, angry, and sad) as they occurred in music and speech stimuli among people with PD and healthy age-matched controls. Results indicated that people with PD perceived emotions less accurately than healthy controls. Anger was identified with significantly more accuracy than sadness and happiness. In addition, accuracy of identification in music was more accurate than speech in people with PD. The results of the study suggest that perception of emotions may be modality specific, or limited only to speech in people with PD.

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CHAPTER I

INTRODUCTION

Parkinson's disease (PD) is a disorder resulting from the deficient production of dopamine producing cells in substantia nigra of the basal ganglia (Kwan & Whitehill, 2011). According to the Parkinson's disease foundation, 60,000 individuals are diagnosed with PD every year in the United States alone with over 10 million people worldwide living with the disease (2016). Reduction of dopamine in the basal ganglia interferes with the motor loop of the brain resulting in movement deficits (Kwan & Whitehill, 2011). PD was traditionally believed to be a movement disorder, the most common symptoms being bradykinesia, tremor, and muscle rigidity. Current research suggests that in addition to motor deficits, people with PD also present with many non-motor symptoms such as hearing loss, negative mood characteristics, cognitive impairments and perception deficits (Schneider & Obeso, 2015).

Among the non-motor symptoms, emotional processing deficits in people with PD have gained considerable attention over the past few years (Benke, Bösch, & Andree, 1998; Breitenstein, Van Lancker, Daum, & Waters, 2001; Lima, Garrett, & Castro, 2013; Péron, Dondaine, Le Jeune, Grandjean, & Vérin, 2012; Wieser et al., 2006). The

previously held view that emotional deficits in people with PD are attributable to their motor deficits has been strongly contended by studies over the past decade (Breitenstein et al., 2001; Pell & Leonard, 2003). Emotional processing refers to the ability to recognize, experience, and express emotions both consciously and unconsciously (Leentjens, 2015). Adolph (2002) described the neural correlates involved in processing of emotions. According to Adolph, the process of recognizing and interpreting emotions does not involve just one structure of the brain but multiple regions regardless of the emotion that is processed.

Some of the commonly implicated brain areas involved in processing of emotions are the amygdala and basal ganglia. Emotions processed auditorily, such as those present in speech, are dependent on signals conveyed through the vocal acoustic cues (amplitude and frequency variation). These acoustic cues traverse through the central auditory pathway beginning from the cochlea in the inner ear all the way through the central auditory cortex. Along with the primary auditory cortex, there are auditory cortical regions surrounding the primary auditory cortex that play a special role in processing emotions. Additionally, the roles of the basal ganglia, right hemisphere, and the frontoparietal regions of the brain cannot be downplayed. Thus, it is not surprising that individuals with PD who present with deficits at the level of basal ganglia exhibit emotional processing problems. The following sections review studies that have investigated processing of vocal as well as non-vocal musical emotions in individuals with PD.

CHAPTER II

REVIEW OF LITERATURE

Processing of vocal emotions

Previous studies have indicated that PD results in differences in the processing of vocal emotions compared to healthy individuals. As a part of a larger experiment, Benke, Bossch, and Andree (1998) examined processing abilities of 48 non-demented individuals with PD. The participants were further divided into two groups based on their cognitive abilities, of which one group had intact cognitive abilities ($N = 26$), and another group demonstrated cognitive deficits ($N = 26$) as revealed by their performance on a test of verbal memory. The participants listened to 24 tape-recorded statements with neutral affective content, which were read slowly and with a strong affective expression. The participants were required to recognize the correct emotion by pointing to one of four printed verbal descriptors (angry, surprised, sad, and cheerful). Correct responses received two points, one point after a single repeated presentation and zero points in the case of incorrect responses. Results revealed that participants with intact cognitive abilities did not have issues in perceiving emotion while participants with cognitive deficits were compromised in emotional processing abilities.

Breitenstein, Lancker, Daum and Waters (2001) examined the contributions of

working memory and acoustic parameters (speech rate and Fo variability) in processing of emotions among 20 German patients with PD and 16 healthy controls. All the participants listened to two different stimuli. The first stimulus included the Subtest 8b of the Florida Affect Battery, which consists of 32 emotional prosodic stimuli, spoken by a female voice. The second stimuli were 20 sentences from a standardized set of emotional prosodic utterances. The stimuli presented five categories of emotions: happy, sad, angry, frightened, and neutral. Results indicated that participants with moderate severity of PD were impaired in emotional processing. The authors attributed this to a likely deficit in the response inhibition system. The impaired performance of patients with moderate PD could be due to either a failure in the response inhibition system (e.g., inability to suppress the semantic content or to selectively focus on the prosodic channel) or to an insufficient activation of the parallel pathway (e.g., reinforcement of the prosodic meaning). Specifically, patients with PD were less efficient in utilizing temporal changes as a cue to processing two emotions: “happy” and “sad.”

Borg et al. (2012) investigated how participants with PD performed in lexical decision making tasks and emotional categorization tasks when compared to healthy controls. When presented with lexical decision making tasks as well as emotional categorization tasks among the emotions of fear, disgust, and happiness, based on word stimuli, patients with PD displayed differences compared to healthy individuals. Thus, the findings suggest that participants with PD chose fewer correct responses than the healthy controls in emotional categorization tasks with the most significant deficits in the identification of "disgust." The findings indicated deficits in identification of semantic content as well as emotional content existing in words. Schröder et al. (2006) mentioned

that those with PD display reduced abilities in classification of emotional prosody of speech, with the poorest performance occurring in the categorization of sad stimuli as indicated by amplitude of electroencephalogram.

Dara, Monetta, and Pell (2008) compared the performance of 16 non-demented patients with PD to 17 healthy controls in identifying basic emotions from prosody and judging affective properties of the same vocal stimuli, such as valence or intensity. The participants listened to pseudo-utterances that reflected seven emotional states (anger, disgust, fear, sadness, happiness, pleasant, surprise, and neutral) and two distinct levels of perceived emotional intensity (high, low). The participants identified the emotional meaning of the prosody for each utterance (identification task), rating the valence of the stimulus (positive or negativity of the stimulus), and intensity of the expressed emotion. Results revealed that participants with PD had difficulties in identifying the emotional prosody and also had a decreased sensitivity in rating the valence but not intensity of anger, disgust, and fear.

Processing of non-verbal emotions

Previous studies have not only assessed the emotional processing abilities of individuals with PD using verbal stimuli but also non-vocal stimuli. Music has been a favored stimulus to evaluate processing of emotions in individuals with PD (Lima et al., 2013). Music has frequently been used throughout history as a tool to convey emotional expression. Fritz et al., (2009) investigated whether participants could recognize three basic emotions as they were expressed in Western music. Music representing the emotions: happy, sad, and scared/fearful were played to both African (Mafa) and Western participants. It was found that people of both population groups correctly recognized all

the emotions represented by Western music. These results may serve to indicate that emotions in music may be recognized universally (Fritz et al., 2009).

Van Tricht et al. (2010) investigated emotion recognition in music in 20 patients with idiopathic PD and 20 healthy controls in addition to the role of cognitive dysfunction and disease characteristics. The authors used 32 musical excerpts that expressed happiness, sadness, fear or anger. The results revealed that patients with PD struggled to recognize fear and anger in music. The deficits in recognition of emotions persisted even after adjusting for executive functioning. There were no differences in the recognition of happy or sad music. Emotion recognition was not related to depressive symptoms, disease duration or severity of motor symptoms.

Lima, Garrett, and Castro (2013) compared the processing of emotions that were presented through verbal as musical modalities in 24 non-demented patients with PD and 25 healthy controls. The researchers examined four emotions in speech as well as musical modalities, two of which were negative. Participants listened to each music excerpt, or spoken sentence four times, and identified one of the four emotions (happiness, peacefulness, sadness, and fear) using a forced-choice paradigm. The results revealed of the four emotions presented through the music modality, patients with PD had trouble identifying happiness and peacefulness. Whereas in the case of speech, the patients with PD had a global impairment and this was significantly related to the presence of executive dysfunction.

Statement of the problem

Past research has indicated that listeners recognize vocal emotions based on speech prosody. There has been compelling evidence to suggest the prominent role of basal ganglia in processing speech prosody (Dara, Monetta, & Pell, 2008). It is unsurprising that individuals with PD who have impaired basal ganglia functioning struggle to infer vocal emotions. Moreover, this is supported by other studies that have consistently found that individuals diagnosed with mild to moderate PD have impairment in processing emotions based on the speech prosody. But, based on the above reviewed studies it is clear that individuals with PD not only have problems in processing verbal emotions but also have problems in processing emotions presented through non-verbal modalities (e.g. music). The trend of the literature indicates that individuals with PD have a global perceptual deficit with regard to processing emotions. This theory, however, has not been systematically investigated, which is a major drawback of the aforementioned studies.

Only one study has compared the processing of emotions presented verbally and non-verbally (Lima et al., 2013). Two primary limitations of this study were that the emotions presented were similar in nature and not appropriately field-tested. The researchers presented five emotions (happiness, peacefulness, sadness, and fear) through music and speech modalities. Results indicated that participants with PD had errors in identifying happiness and peacefulness. It is possible that the participants confused the two emotions as they are similar in nature and can be challenging to distinguish one from another. Selecting emotions that are distinct from one another while pursuing this line of research is of great importance. Additionally, it is also necessary to test the reliability of findings in previous studies. To our knowledge, only one study has investigated

emotional processing in PD by comparing perception in speech and music. This line of research will help us understand whether this emotional deficit in PD is modality specific (e.g., speech only) or generalized to multiple modalities.

Considering the above limitations, the proposed study systematically compared emotional perception in persons with PD to age-matched healthy controls in identifying three emotions (e.g., happiness, sadness, anger). In addition, the stimuli were systematically field-tested in order to ensure good reliability. Based on the theoretical underpinnings of emotional processing, it was hypothesized that people with PD presented with deficits in perception of emotions in speech and music when compared to healthy age-matched controls.

CHAPTER III

METHODS

Participants

Participants included 15 individuals with PD (clinical group) and 15 healthy age-matched controls (control group) aged 50 or older. The participants were recruited through convenience sampling procedure from the community and local support groups affiliated with the Parkinson Foundation of Oklahoma. All participants spoke English as their first language. The clinical group was administered the Movement Disorders Society Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS) to assess levels of cognitive and motor functioning and severity of the disease. Both groups were given a hearing screening and the Montreal Cognitive Assessment (MoCA) to document levels of cognitive functioning and screen for dementia and depression.

Clinical group participants who presented with marked cognitive impairment were excluded from participation as determined by scores of the MoCA and UPDRS. MoCA scores ranged from 24-30 in both groups. Participants with scores below the passing score of 26 were excluded only if responses occurred as outliers. UPDRS scores

ranged from 2-62. Similarly, scores consistent with significant progression of motor symptoms were included as long as responses did not present as outliers. Participants with hearing loss were included as long as they owned hearing aids, used amplification, and responses did not present as outliers. Clinical group participants who underwent deep brain stimulation surgery (DBS) were not excluded from the study. Individuals belonging to the control group who had a history of cognitive, motor, and/or sensory impairments were excluded from participation. Groups did not vary significantly in terms of prior music experience or age. Music experience was defined in terms of performance in ensembles (i.e., choir, band) as well as private lessons. Personal interest in listening to music was not factored into this category. Background information of study participants is illustrated below in Table 1.

TABLE 1
Background characteristics of participants with PD and healthy age-matched controls

Characteristics	*Clinical Group (n = 15)*	*Healthy Control Group (n = 15)*
Age	69.7	69.3
Gender	9M/6F	7M/8F
Disease Duration	3.3	–
Motor UPDRS	30.1	–
Hoehn and Yahr	2.13	–
MoCA	26.1	26.3
Hearing Screening	9 pass/6 refer	12 pass/3 refer
No Music Background	4	6
Music Experience (Avg. Years)	13.2	12.1

Note. M = male, F = female. UPDRS = Unified Parkinson's Disease Rating Scale. MoCA = Montreal Cognitive Assessment.

Stimuli

A university music professor designated multiple pieces of classical music, each representing three emotions: happiness, sadness, and anger. Works of music without

lyrics were chosen in order to prevent lyrics from impacting the emotional perception. Music recordings, 10-15 seconds (s) in length, were spliced and modified from the larger works, by the researcher, using Audio Edit Studio Lite software. Selections were shortened in order to adequately sustain the attention of the participants while also conveying the complete musical phrase. The shortened length of music excerpts attempted to prevent familiarity effects from interfering with performance of participants during the recognition task. Of the 15 music recordings, 10 were collected representing each emotion for a total of 30. Similarly, a female student actor was elected to verbally produce phonetically balanced sentences containing neutral content words but also representing the aforementioned emotions. This was accomplished solely through the use of prosody, intonation, volume, and pitch changes of the voice. The sentences utilized in the study were obtained from the Harvard sentences collection (IEEE Recommended..., 1969). The speaker produced 10 sentences for each emotion for a total of 30. Care was exercised to ensure that sentences were produced in a natural way without exaggeration.

The music samples as well as the verbal sentences were field-tested among a class of 50 undergraduate students. The students were required to label the emotion in a forced-choice task after listening to each music and speech excerpt. Students also indicated the intensity (e.g., strength) of emotion on a 5-point rating scale; one being of low intensity and five being the highest intensity possible following every recording. The students were provided with data collection worksheets to document responses. The top five music and speech stimuli were nominated for each emotion category (e.g., happy, sad, angry) for a total of 30 selections. The top five music and speech recordings, most accurately and consistently identified for each emotion category, were selected as

the final stimuli for a total of 30 emotional samples. All music and speech selections were correctly identified with at least 99% accuracy. The final stimuli were randomized and placed into three distinct playlists in order to control for potential order effects.

Procedure

The experiment was conducted in the home of participants for convenience purposes. The room of the home was an area free from auditory and visual distractions. All participants were seated at a table for the entire duration of the experiment. Participants listened to the speech and music playlists at a comfortable loudness level using noise-reducing headphones. As outlined in the "Stimuli" section, each recording depicted one of the three emotions via music or speech. Participants indicated which emotion they believed was conveyed by the recording by either depressing the corresponding button of the button response system or verbally stating their choice aloud.

The custom-made system was comprised of four different colored buttons with each colored button representing one of four emotions: happiness, sadness, anger, and neutral. Though no samples were created to specifically represent 'neutral,' the option was added in order to decrease the chance factor (e.g., guessing a correct answer that was not actually perceived). A visual illustration of the emotion was provided on each button as a visual aid for participants to identify with. Each button was large and spaced a fair distance apart to accommodate for potential tremors interfering with responses. A schematic representation of the button response system is shown in Figure 1. After indicating their choice of emotion, each participant also indicated the valence of the

emotion they chose using a 5-point rating scale. A sliding scale with five points at equally appearing intervals was used for this purpose, where "1" indicated that the emotion was perceived at a low intensity (e.g., very weak) and "5" the strongest intensity with which the particular emotion was perceived

Figure 1. Button Response System utilized by participants to indicate their choice of emotions during response task.

Prior to the start of the experiment, participants were instructed on the nature and goals of the project. They were briefed on how to listen to recordings and provide responses. Six practice selections were played for the participants (one for each emotion in both music and speech). During each practice sample, the clinician ensured that the participant was correctly using both the button response system and the sliding scale. Correct responses were provided if the client answered incorrectly and a short explanation of the correct response (e.g., The correct response was sad. In sad speech, the rate is slowed, prosody is lessened, and pitch is lower than in typical speech.). Afterwards, the participants were presented with 30 audio recordings with each sample averaging for duration of 5-15 s.

The researcher manually presented the speech and music selections using iTunes from a laptop running Windows operating system. Each participant was allowed to hear

the recording as many times as required. If one did not wish to hear the audio sample repeated, then he/she was given one minute to indicate his/her response. Participants indicated a "closed-choice response" by depressing the button that matched with the emotion they perceived. Following the closed-choice response, the participant indicated the valence of emotion on the sliding scale.

Statistical Analysis

Two types of analyses were carried out for this project. The first analysis compared the accuracy scores of the clinical and control groups using a 2*2*3 mixed model analysis of variance (ANOVA). The between-subject factor was the participant groups and the within-subject factors were the type of stimulus (music and speech) and type of emotion (happy, sad and anger). The accuracy score for each participant was calculated as the number of correct responses. This accuracy score was later converted into percentage score for statistical analysis. The ANOVA tests yielded an F value, p value, and partial eta squared (η^2) to determine the effect size. The second analysis examined the strength of the perceived emotion between the clinical and control group using Pearson product moment correlation. The alpha was set at 0.05.

CHAPTER IV

FINDINGS

Participant Age

The age of the participants in both the groups were compared using independent sample *t* test and the results revealed that there was no significant difference between both the groups $t\ (28) = 0.02$, $p > 0.05$.

Results

The statistical analysis for the current project was carried out using SPSS 23.0. The current study compared accuracy in identification of emotions among individuals with PD and age-matched healthy controls. Emotions were presented through both speech and music. Happiness, sadness, and anger were the emotions assessed in the current study. The three-way mixed model ANOVA revealed a significant main effect of the emotions, $F\ (2, 56) = 4.28$, $p < 0.05$, $\eta^2 = 0.13$. The participants perceived anger better ($M = 83.68$; $SD = 22.46$) when compared to happiness ($M = 74.00$; $SD = 21.67$) and sadness ($M = 73.67$; $SD = 25.77$). There was also a significant main effect of the type of stimulus, $F\ (1, 28) = 32.89$, $p < 0.05$, $\eta^2 = 0.54$. The participants perceived emotional

music better (M = 86.67; SD = 11.23) than emotional speech (M = 67.56; SD = 17.59). These main effects were qualified by significant interaction of Stimulus*Emotion, F (2, 56) = 8.90, $p < 0.05$, $\eta^2 = 0.24$, and Stimulus*Group, F (1, 28) = 6.13, $p < 0.05$, $\eta^2 = 0.18$.

Table 2

Accuracy Scores, Mean, and Standard Deviation of Participants with PD

Clinical Group						
	Music			Speech		
Participant	Happy	Sad	Anger	Happy	Sad	Anger
1	100	100	100	80	100	100
2	0	80	100	80	40	80
3	100	80	60	60	40	100
4	100	100	100	40	20	40
5	100	100	100	40	80	100
6	100	80	40	60	40	40
7	100	100	100	0	60	100
8	100	100	80	60	20	60
9	80	100	100	20	80	60
10	60	100	100	60	100	60
11	80	100	80	20	0	80
12	100	60	80	40	20	100
13	60	100	40	80	40	20
14	100	60	80	100	80	80
15	80	100	100	60	20	60
Mean (M)	84.00	90.67	84.00	53.33	49.33	72.00
SD (SD)	27.46	14.86	21.65	26.9	31.95	25.97

Note. Accuracy scores were calculated by percent (%) out of five total available for each emotion (e.g., happy, sad, anger) and type of stimuli (e.g., music, speech).

Table 3

Accuracy Scores, Mean, and Standard Deviation of Healthy Controls

Control Group						
	Music			Speech		
Participant	Happy	Sad	Anger	Happy	Sad	Anger
1	100	100	100	80	60	80

2	60	60	80	40	20	100
3	80	80	80	20	80	100
4	80	80	80	60	40	80
5	100	100	80	80	100	100
6	100	80	100	80	80	100
7	100	100	100	100	100	100
8	100	80	80	60	80	100
9	100	80	100	20	20	100
10	80	100	100	80	40	80
11	100	100	100	80	100	100
12	100	80	60	80	100	100
13	100	60	80	60	60	80
14	100	80	60	60	100	100
15	100	80	80	80	80	80
Mean (M)	93.33	84.00	85.33	65.33	70.67	93.33
SD (SD)	12.34	13.52	14.07	23.26	29.15	9.76

Note. Accuracy scores were calculated by percent (%) out of five total available for each emotion (e.g., happy, sad, anger) and type of stimuli (e.g., music, speech).

The post hoc test analyzing that interactive effect of Stimulus*Group revealed that individuals with PD perceived emotional music ($M = 85.78$; $SD = 15.89$) better than emotional speech ($M = 58.67$; $SD = 24.82$) ($p < 0.05$). However, participants in the control group perceived emotional music and speech in the same manner ($p > 0.05$). The simple effect analysis of Stimulus*Emotion revealed that participants perceived happy music ($M = 88.0$; $SD = 29.76$), sad music ($M = 87.30$; $SD = 20.05$), and angry music ($M = 84.67$; $SD = 25.77$) better than respective happy ($M = 60.0$; $SD = 33.67$), sad ($M = 62.0$; $SD = 40.87$), and angry speech ($M = 80.66$; $SD = 33.44$) ($p < 0.05$). There was also a significant difference in emotional perception of individuals with PD and control group participants, $F(1, 28) = 5.88$, $p < 0.05$, $\eta^2 = 0.17$. The participants in the control group ($M = 82.00$; $SD = 15.72$) perceived emotions more accurately than the PD group ($M = 72.22$; $SD = 15.78$).

The strength of perceived emotion was compared across the clinical group and control group using a series of Pearson product moment correlation. The participants in both the groups were compared for strength of perceived emotions including happiness ($r = 0.26$), sadness ($r = 0.29$), and anger ($r = 0.23$). All these correlations were significant ($p < 0.01$). The strength of perceived emotions of participants were also compared across stimulus type (music and speech). The results revealed that there was significant correlation across the groups for emotional music ($r = 0.17$) and emotional speech perception ($r = 0.23$) ($p < 0.05$) although these correlations were weak in nature.

TABLE 4

Valence (Strength) of Perceived Emotions Between Groups

Type of Stimulus	*Correlation*
Anger	$r = 0.23$
Happiness	$r = 0.26$
Sadness	$r = 0.29$
Type of Stimulus	*Correlation*
Music	$r = 0.17$
Speech	$r = 0.23$

Note. All correlations comparing strength of emotions between groups were significant ($p < 0.01$). A significant correlation was also found between stimulus type (e.g., music and speech) between groups though correlations were weak ($p < 0.05$).

CHAPTER V

CONCLUSION

This study provided evidence that people with PD perceive emotions less accurately than healthy age-matched controls. As anticipated, results of the current study supported the original hypothesis. Trends in data may indicate that the loss of dopamine in the brain negatively impacts emotional perception abilities in people with PD. It was interesting to note that participants with PD perceived music more accurately than speech. Though unexpected, it is not without precedent. Prior research suggests that music may serve as a modality to which parallels may be drawn to speech prosody (Harris et al., 2016; Hefner & Slevc, 2015). Supporting this connection, the current study found that ratings of valence between groups were similar, though the between-group correlation was weak. Participants with PD did not always accurately identify emotions, but perceived strength congruently to healthy controls.

In addition to a between-group correlation, results indicated that anger was more accurately identified than sadness and happiness. Findings of the current study may serve to support the theory that different areas of the brain are activated for perception of emotions in music when compared to emotional speech. Little research in the area of emotional perception in people with PD has been completed and research that has

yielded mixed results. The following sections seek to compare the current study with the available evidence related to this topic.

Music and Speech

The current study found that people with PD correctly identified all emotions in music more accurately than those as presented through emotional speech. This contradicted with the findings of Lima et al. (2013), which identified deficits between both modalities. Lima et al. found that positive emotions (happiness, peacefulness) were impaired, but negative emotions (sadness, fear) remained intact when presented through music. In speech, only a global deficit was found, which opposes findings of the current study. Pre-existing research supports the notion that correct identification of emotions during speech prosody tasks is impaired in people with PD (Borg et al., 2012; Schröder et al., 2006). Correlation, though weak, was indicated between both groups in valence ratings of emotions. The healthy control group rated the strength of emotions in a similar manner to the clinical group. This finding contradicts previous research, which indicates that people with PD may demonstrate a reduced sensitivity in rating of valence (Dara, Monetta, & Pell, 2008). The current study supports the theory that deficits in perception of emotions among people with PD are limited to a single modality, speech.

Inconsistencies between findings of the current study and past studies may be attributed, in part, to differences in methodology. The current study utilized systematic field-testing of music and speech recordings prior to their employment in data collection. A similar study drew from established databases for music and speech selections (Lima et al., 2013). Only three emotions were investigated in this study, reducing potential for

confusion of similar emotions. Previous studies investigated different and a greater number of emotions which may have prompted results contrasting with the current study (Dara, Monetta, & Pell, 2008; Lima et al., 2013; Van Trichet et al., 2010). Differences also existed in how ratings of accuracy and valence were collected in this study, compared to previous studies. This may have prompted these inconsistencies between results.

Language differences may have been another variable resulting in disagreement between the current study and some studies. Lima et al., 2013 drew from a validated database containing neutral sentences with variations in prosody but sentences were presented in Portuguese while the current study employed sentences of the English language. It may be possible that the strength of emotions could be perceived differently due to differences between languages. Differences in methodology and languages may be able to explain inconsistencies in research in part; however, neuroanatomical activation as well as theories of human development and environmental conditioning may also support results presented by the current study.

Emotion-Specific

The clinical group in the current study demonstrated an increased ability to identify anger in speech and music stimuli when compared to sad and happy stimuli. Few studies have been completed that systematically investigate the perception of emotions in people with PD. Among those that have, research examining how emotions are perceived in music is limited. Previous studies have provided evidence that both supports and conflicts with results obtained in this study. Lima et al. (2013) provides support for this conclusion. Lima and colleagues surmised that people with PD correctly identified

happiness and peacefulness less accurately than negative emotions such as sadness and fear. Though not specifically investigated in the study, anger may be considered a negative emotion along with sadness and fear.

Another study completed among participants with PD was found to be incongruent to the current study regarding perception in music (Van Tricht et al., 2010). Participants with PD demonstrated impairment in their ability to recognize anger and fear, while no differences were found in abilities to identify happiness or sadness. Specific to speech, additional evidence exists indicating that people with PD struggle more with recognizing negative emotions like anger, rather than positive emotions (Breitenstein et al., 1998; Pell & Leonard, 2003). The current study contradicts these findings in concluding that darker, more negative emotions as anger or sadness were perceived more accurately than positive emotions like happiness.

As has been hypothesized and established by previous studies, anger, when presented through speech prosody, activates a greater number of brain regions with greater intensity when compared to other emotions (Castelluccio et al., 2016; Dara, Monetta, & Pell, 2008). This may be attributed to a different neural network in the processing of anger compared to other emotions. A functional magnetic resonance imaging (fMRI) study found that anger, as conveyed through speech prosody, engaged both hemispheres of the brain including bilateral temporal areas, inferior frontal gyrus, occipital areas (bilateral middle occipital gyrus and right lingual gyrus), right posterior cingulate gyrus, right insula, right precuneus, and bilateral cerebellum (Castelluccio et al., 2016). The brain displayed greater activation in response to speech prosody representative of anger when compared to neutral prosody.

Dara and colleagues demonstrated this increased activation in a study reviewed in chapter two (page 12). People with PD rated speech recordings that represented anger, fear, and disgust as significantly more intense when presented with emotional speech prosody (Dara, Monetta, & Pell, 2008). The processing of happiness and sadness may utilize structures of the brain that are negatively affected by a loss of dopamine whereas negative emotions (i.e., anger) do not. Furthermore, structures are not activated to the same magnitude they are in response to anger.

This may be due to a number of explanations related to evolution and survival of the human species. The primary goal of humans has always been to maintain survival and thrive. Because of this, when humans are presented with anger, it may be perceived as a threat with the possibility of bringing harm to one's life or wellbeing. Perceived attacks may lead to activation of the fight-or-flight response in humans, or timed release of adrenaline by the sympathetic nervous system, in order to effectively ensure survival and/or survival of offspring. This adaptive response may potentially aid humans in accurately recognizing and responding appropriately to anger.

Environmental conditioning may be another factor precipitating enhanced responsiveness of humans to perceived anger. Humans are conditioned by society from birth to be aware of threatening cues and social norms. Anger contains acoustic cues that are difficult to mistake. Qualities such as prosody, tone, and increased volume of the voice carry little likeness to other emotions (i.e., happiness, sadness). As a result of adaptive responses for human survival, environmental conditioning, and acoustic cues conveyed through speech, it is very possible for participants with PD to have responded with greater accuracy to stimuli conveying anger in the current study.

Limitations and Future Recommendations

A relative strength of this study was the employment of systematic field-testing of all music and speech recordings prior to their employment among participants. It may be noted; however, that the current study utilized college students for this testing. Future studies seeking to include original stimulus samples should ensure proper field-testing is completed among a population matching the age of the participants. Though attempts were made to combat the issue through the systematic field-testing and shortened duration of recordings (15 s or less), a familiarity effect may have impacted identification of some music selections. Inclusion of original works of music, rather than classical music may counteract this effect. Though participants with hearing impairment had hearing aids, not all passed every frequency during the screening. Future studies may seek to employ a more homogeneous sample, though difficult to come by in adult populations.

Future studies may seek to investigate emotional perception among other nonverbal modalities in comparison to speech, such as art or film clips, among people with PD. Because frequency changes play a major role in how emotions are processed by the brain, formant frequencies would be another interesting line of research. Formant frequencies vary greatly between individuals but some degree of consistency may be present when similar emotions are portrayed through speech. Neuroimaging studies have potential to further confirm or contradict existing theories of emotional perception by providing concrete evidence of what structures are activated during processing of specific emotions in people with PD compared to healthy individuals. Further exploration of brain

activation may also determine how the brain processes emotion such as sadness or happiness differently (Castelluccio et al., 2016).

New information obtained from this study may possess many clinical implications as well. It can be hypothesized that music and speech share structural components with regard to suprasegmental qualities. Similar to rate, a suprasegmental aspect of speech, music includes related elements like meter. Meter refers to the recurrent pace at which beats occur in music. This quality, which is found in both music and speech, determines what notes or syllables will be stressed (Heffner & Eslevc, 2015). Stressed items, in turn have potential to impact the quality or how the music or speech is portrayed. In addition to rate, meter, and stress, other parallels may be drawn between the two. Where music has dissonance conveyed through tritones, modes, or minor key changes (as is seen in sadness or anger), speech has prosody. A high volume in either modality may be considered angry. Because of these parallels, music has potential to perform as an efficient means for remediating deficits in emotional perception among people with PD.

Music has been found to successfully modulate activities of major limbic and paralimbic structures of the brain such as the amygdala and orbitofrontal cortex (Koelsch, 2009). Simply listening to music activates a number of neural processes that may aid in new learning, understanding, and perhaps even predicting intentions of others. A common treatment technique, melodic intonation therapy (MIT), has successfully demonstrated this theory in successful rehabilitation of language skills among people with nonfluent aphasia (Norton et al., 2009). Music therapy treatments are currently being used among the PD population. One of these includes gait rehabilitation through

the use of metronomic rhythmic cues (Hove & Keller, 2015). Future study may seek to develop a new treatment protocol, similar MIT or gait rehabilitation, but using music to remediate emotional perception skills in people with brain changes, like those resulting from PD.

Conclusion

The current study provides support for the theory of differential neurological processing of emotions in people with PD when compared to healthy individuals. Clinical group participants in the study demonstrated greater impairment in identification of emotions in speech when compared to music as well as a heightened ability to recognize "anger." This study corroborates previous research findings that people with PD, without severe cognitive deficits or depression, may exhibit impairment in perceiving emotions. This research also provides support for nonverbal modalities (music) and verbal modalities (speech) utilizing different systems and brain structures for interpretation of emotions. Both clinically and scientifically, the current research study provides evidence with potential to positively impact the daily lives of people with PD.

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APPENDICES

Oklahoma State University Institutional Review Board

Date:	Tuesday, May 23, 2017
IRB Application No	AS1722
Proposal Title:	Investigating speech production and perception in individuals with and without Parkinson's disease
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 5/22/2018

Principal Investigator(s):

Ramesh Kaipa
042 Murray Hall
Stillwater, OK 74078

Chelsea McQuigg
Stillwater, OK 74078

Natalie Miller
Stillwater, OK 74078

Shea Walker

Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☐ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Hugh Crethar, Chair
Institutional Review Board

ADULT CONSENT FORM

OKLAHOMA STATE UNIVERSITY

PROJECT TITLE:
Investigating speech production and perception in individuals with and without Parkinson's disease

INVESTIGATORS:
Ramesh Kaipa, Ph.D., Assistant Professor and Program Director, Department of Communication Sciences and Disorders, Oklahoma State University.

PURPOSE:
People with Parkinson's disease are known the present with speech rate problems as well as inaccurate perception of loudness levels and emotions. However, these three aspects have not been systematically investigated in a study. Considering this limitation, this study will examine how individuals with Parkinson's disease and individuals without Parkinson's disease will respond to modifying speech rate using an App, respond to different emotions and identifying loudness of different speech samples. This study will help us to determine how the neural mechanisms respond to different aspects of speech production and speech perception and will be help us to generate breakthrough findings.

PROCEDURES
You will be asked to participate in two sessions, the first session will be anywhere between 80-100 min, and the second session will last for 45-60 min. During the first session, you will be administered some the following tests: (1) Movement Disorders Society-Unified Parkinson's Disease Rating Scale and (2) Montreal Cognitive Assessment Scale (MoCA) if you are diagnosed with Parkinson's disease. If you do not have Parkinson's disease, you will be administered just the MoCA. During the second session, you will be involved in three experiments. The details of these experiments are mentioned below.

Experiment 1: In this experiment, you will be played some music and speech samples at their comfortable loudness level depicting happy, sad, and angry emotions and they will be required to identify through a button response system. If the patient is not hard of hearing, then the stimuli will be presented at 65 dB SPL. But if the participant uses amplification device, then the stimuli will be presented at a convenient level that the patient can hear effectively. For this reason it is difficult to accurately estimate the loudness level that will be presented.

Experiment 2: You will be required to read a passage that will be recorded and played back to them at five intensity levels of the stimulus (60, 65, 70, 75, and 80 dB SPL). Additionally, you will also be asked to listen to the reading sample at five intensity levels of the stimulus (60, 65, 70, 75, and 80 dB SPL). Following this you will be involved in rating the loudness level of their own speech sample as well as the external speech sample.

Experiment 3: In the final experiment, you will receive altered auditory feedback of their own speech, that would involve delaying the auditory feedback by few milliseconds (100-150 ms) as well as altering the frequency of auditory feedback (about half an octave above or below). This is a very safe procedure commonly used to modify a person's rate of speech. The altered auditory feedback would be administered using a mobile app that is designed specifically for this purpose. This experiment would investigate the effect of altered auditory feedback in increasing the speech clarity of people with PD.

All the experimental sessions will be audio and video recorded for data analysis purposes but this will be maintained confidentially. Each experiment will last for around 15-20 min. All the three experiments will be conducted on the same day. Only the researchers involved in this study will have access to the audio

and video recordings. During the administration of a test and/or experiment if you feel uncomfortable then you can withdraw from the experiment at any time. Participation in this experiment is completely voluntary.

RISKS OF PARTICIPATION:
There are no known risks associated with this project which are greater than those ordinarily encountered in daily life. All these experiments have been routinely used in speech research and intended to understand speech production and speech perception in individuals with and without Parkinson's disease. However, if you feel uncomfortable during the administration of a test and/or experiment if you feel discomfort then you can withdraw from the experiment at any time. Participation in this experiment is completely voluntary.

BENEFITS OF PARTICIPATION:
If you are interested, we will send you a copy of the results of the study when it is finished.

CONFIDENTIALITY:
The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored on a password protected computer in a locked office and only researchers and individuals responsible for research oversight will have access to the records. Data will be destroyed three years after the study has been completed. You will not be identified individually; we will be looking at the group as a whole.

COMPENSATION:
You will receive assistance for transportation. Either the researcher will provide transportation for you and/or you will be reimbursed for your travel.

CONTACTS :
You may contact the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Ramesh Kaipa, Ph.D., Assistant Professor and Program Director, Department of Communication Sciences and Disorders, Oklahoma State University. E-mail:ramesh.kaipa@okstate.edu; Phone number: 405-744-7956.

If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

PARTICIPANT RIGHTS:
I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION:
I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:
I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this study.

_____ _____
Signature of Participant Date

I certify that I have personally explained this document before requesting that the participant sign it.

_____ _____
Signature of Researcher Date

OSU SPEECH-LANGUAGE-HEARING CLINIC

Hearing Screening

NAME_____ DATE_____

CLINICIAN_____ SUPERVISOR_____

I. Pure Tone Screening: Pass (P)/ Fail (F).
Child - screening at **20 dB HTL Adult – 25 dB**

	1000 Hz	2000 Hz	4000 Hz
Right Ear			

	1000 Hz	2000 Hz	4000 Hz
Left Ear			

II. Middle Ear Screening: See Attached Tympanogram

Right Ear		Left Ear
_____	Classification (A, A_s, B, C, A_d)	_____
_____	Canal Volume	_____
_____	Admittance Peak	_____
_____	Pressure Peak	_____

III Results: PASS_____ FAIL_____

IV. Recommendations:

Rescreen annually_____ Audiological Referral_____ Medical Referral_____

Revised 07/21/05

Medical Questionnaire

Age:

Sex:

When were you diagnosed with Parkinson's disease?

Can you tell me a bit about your Parkinson's disease (has it been increasing in severity or has it remained stable over the years):

Do you have any other medical conditions (e.g. cognitive problems, anxiety, speech problems, sensation problems):

Details of medication for Parkinson's disease:

Do you have any other problems that you wish to share with us?

Do you want to have a copy of the test results? Yes/No (please circle your choice)

Participant: _____

Playlist: ____

Data Collection Sheet

Sample Selections:

#	Happy	Sad	Angry	Neutral	Valence (1-5)
1.					
2.					
3.					
4.					
5.					
6.					

Actual Data:

#	Happy	Sad	Angry	Neutral	Valence (1-5)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					

#	Happy	Sad	Angry	Neutral	Valence (1-5)
25.					
26.					
27.					
28.					
29.					
30.					

Ask the participant/caregiver how much music training they have had (e.g., band, choir, etc.) and the number of years they participated:

VITA

Chelsea McQuigg

Candidate for the Degree of

Master of Science

Thesis: PERCEPTION OF EMOTIONS IN MUSIC AND SPEECH IN PEOPLE WITH PARKINSON'S DISEASE (PD) AND HEALTHY AGE-MATCHED CONTROLS

Major Field: Speech-Language Pathology

Biographical:

Education:

Completed the requirements for the Master of Science in Speech-Language Pathology at Oklahoma State University, Stillwater, Oklahoma in May, 2018.

Completed the requirements for the Bachelor of Arts in Music at Oklahoma Baptist University, Shawnee, Oklahoma in May, 2013.