The Impact of Parkinson's Disease on Social Perception: Preliminary Evidence

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Abstract

Besides motor symptoms, people with Parkinson's Disease (PD) often exhibit social cognition difficulties. The assessment of social cognition in early PD is crucial, as these deficits may impact patients' social interactions and quality of life. The current study used naturalistic, dynamic video clips to examine the ability of individuals with idiopathic PD to perceive speaker intentions in comparison with healthy controls (HC). Neuropsychological evaluation of the PD patients was conducted using the Cognitive Linguistic Quick Test (CLQT). Video stimuli were taken from the Relational Inference in Social Communication database (RISC; Rothermich & Pell, 2015) and contained literal, sarcastic, and teasing scenes. The participant's task was to identify the speaker's belief, i.e., if they were sincere or insincere. The results show that in general, all participants had a harder time identifying nonliteral statements such as teasing as insincere when compared to literal statements. A group analysis demonstrated a marginally significant effect between people with PD and HCs, showing that individuals with PD were less accurate in recognizing social intent compared to HC. This difference was possibly driven by changes in cognitive abilities due to the progression of PD. Indeed, analyses for the PD group revealed positive correlations between several cognitive domains, such as attention and memory, and performance on the speaker belief task. Taken together, our study sheds light on the relationship between cognitive mechanisms and social perception impairments in PD and supports the development of targeted tools for diagnosing and treating these impairments.

Keywords: Parkinson's Disease, social communication, nonliteral language, pragmatics, audiovisual processing

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In the United States, Parkinson's Disease affects about one million people (PD; Marras et al., 2018). PD is a neurodegenerative disorder caused by a decline in substantia nigra dopaminergic neurons leading to motor and non-motor symptoms. Typical motor symptoms include bradykinesia, rigidity, and tremor (Sveinbjornsdottir, 2016), while common non-motor symptoms include sleep dysfunction, neuropsychological/behavioral issues, and cognition impairments (e.g., Park & Stacy, 2009). Decline in social cognition abilities such as Theory of Mind (ToM), empathy, emotion processing, and nonliteral language perception have also been demonstrated in people with PD (for recent reviews see Alonso-Recio et al., 2020; Coundouris et al., 2020; Palmeri et al., 2017; Seubert-Ravelo et al., 2021). In particular, people with PD exhibit difficulty interpreting speaker intentions and impairments in analyzing facial expressions and decoding prosodic cues (Monetta et al., 2009; Pell et al., 2014).

Social cognition is an umbrella term that describes cognitive processes related to the perception, recognition, understanding, and use of social cues in everyday situations (Harvey & Penn, 2010). Social cognition impairments appear early in PD and can precede motor dysfunctions (Turcano et al., 2019). More precisely, people with PD can display deficits in processing social aspects of language, emotion recognition, perspective taking, and understanding nonverbal cues during conversation (McNamara & Durso, 2003; Monetta et al., 2009; Pell et al., 2014). Due to the lack of appropriate social cognition assessment tools for people with PD, these deficits often go undiagnosed, leading to a lack of interventions and a decreased quality of life (van Uem et al., 2016). This is especially surprising because recent evidence suggests that these impairments occur in about 30% of persons with PD (Czernecki et al., 2021); they frequently arise within 4 years of diagnosis (Poewe, 2008). However, there is currently no clinical standard for assessing or providing interventions for these impairments. It is crucial to enhance our knowledge about these deficits, since they often cause problems with communication, loneliness, and social isolation (Monetta et al., 2009; Prenger et al., 2020).

One possible reason for social cognition impairments in PD are difficulties with attention, working memory, and executive functions (Aarsland et al., 2011; Alonso-Recio et al., 2020; Assogna et al., 2010; Dirnberger & Jahanshahi, 2013; Narme, Bonnet, Dubois, & Chaby, 2011). It is possible that social cognition deficits in PD are in part caused by cognitive resource impairments, most likely due to overlapping neural circuits (Alonso-Recio et al., 2020). Until now, researchers have mainly looked at the relationship between social cognition and cognitive functioning in the context of executive functions. However, the findings are inconclusive (Alonso-Recio et al., 2020), and there is less data on other cognitive domains, such as memory and attention.

Another reason for social cognition deficits could be the inefficient use of visual (e.g., facial expression) and auditory (e.g., prosodic inflection) cues, which are critical for avoiding misunderstandings of social information during conversations (e.g., Albuquerque et al., 2016; Péron et al., 2012; Suzuki et al., 2006). To test social cognition abilities in people with PD, we developed the Relational Inference in Social Communication (RISC) video database (Rothermich & Pell, 2015). RISC offers the possibility to study four major social cognition skills that are crucial for successful

communication: auditory social perception (e.g., emotional prosody), visual social perception (e.g., facial expressions), ToM (e.g., cognitive perspective taking, identifying speaker intentions), and empathy (e.g., affective perspective taking). Previous studies often utilized static images or written vignettes to examine social cognition in PD (e.g., Bodden et al., 2010; Monetta, Cheang, et al., 2008; Péron et al., 2009; Roca et al., 2010; Shamay-Tsoory, Tomer, Berger, & Aharon-Peretz, 2003), which lack social context and dynamic interpersonal cues. The RISC database offers context-rich scenarios with a full array of auditory and visual cues.

Each RISC video contains a short conversation between two adults, during which they use prosody, facial expressions, gestures, and body language to convey the meaning of their conversations. We thereby focus on four different speaker intentions: literal positive, blunt, teasing, and sarcasm. Nonliteral language such as sarcasm or teasing are frequent in daily interactions and require audio-visual perception as well as social cognition skills, such as emotion processing and perspective taking. Sarcasm and teasing both serve specific social-pragmatic functions (Jorgensen, 1996; Toplak & Katz 2000). Sarcasm, also known as ironic criticism, is defined here as a positive statement with negative intentions that is often used to express humor and indirectly infer criticism (Sveinbjornsdottir, 2016; Shany-Ur et al., 2012 & Caucci & Kreuz, 2012). Teasing, also called an ironic compliment, is often used to convey humor and banter (Katz et al., 2004). This usually describes a negative statement that has a positive intention.

Current Study

The current study seeks to investigate the relationship between social perception abilities and cognitive skills in persons with PD. To achieve this goal, we used a neuropsychologic assessment battery and a performance-based task. We hypothesized that participants with PD would display poorer accuracy in identifying speaker intentions in comparison to healthy, age-matched control participants (e.g., Holtgraves & McNamara, 2010; Monetta et al., 2009; Pell et al., 2014). Based on previous studies, we also expected those participants with impaired limited cognitive resource capacity to perform worse than people with relatively intact cognitive skills (e.g., Monetta et al., 2009; Pell et al., 2014; Vachon-Joannette, Tremblay, Langlois, Chantal, & Monetta 2013).

Methods

Participants

A total of 13 participants with PD took part in the current study (5 female/8 male; mean age=66.5). All 13 participants with PD were screened for cognitive abilities using the Cognitive Linguistic Quick Test (CLQT). The participants with PD were recruited from support groups throughout Eastern North Carolina and were compensated with \$40 gift cards. They also completed a hearing screen to adjust loudness levels during the experiment. The 13 healthy controls were recruited via the Prolific Academic website (<https://app.prolific.ac>), an online recruiting platform. Online recruits were compensated \$13.50 for participating. The control participants took part in a companion study about nonliteral language perception across the life span (Rothermich et al., 2021), using the same set of stimulus materials. All participants gave consent before beginning the experiment. Out of the PD participants, one person had previously experienced a stroke.

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Another person with PD scored higher than threshold for depression and was instructed to consult a mental health professional (see **Table 1** for more details on patient demographics).

Table 1. Patient demographics

							CLQT Scores				
N°	Age	Sex	Dur	HY	CP	AN	CLQT	EX	LG	VS	CD
1	69	M	12	3.0-4.0	Mild	Moderate	Mild	WNL	WNL	Mild	WNL
2	65	F	3	1.0 or 1.5	WNL	WNL	Mild	WNL	WNL	WNL	WNL
3	72	M	3	2.5	WNL	Mild	WNL	WNL	WNL	WNL	WNL
4	62	F	3	2	Mild	Moderate	WNL	WNL	WNL	Mild	WNL
5	69	M	7	2.5-3.0	WNL	WNL	WNL	WNL	WNL	WNL	WNL
6	59	F	5	2.0-2.5	WNL	WNL	WNL	WNL	WNL	WNL	WNL
7	62	F	9	2.5	WNL	WNL	WNL	WNL	WNL	WNL	WNL
8	59	M	14	1	WNL	WNL	WNL	WNL	WNL	WNL	WNL
9	58	M	14	1.5	WNL	WNL	Mild	WNL	WNL	WNL	WNL
10	80	M	9	2.5-3.0	WNL	WNL	WNL	WNL	WNL	WNL	WNL
11	77	M	3	1.5-2.0	Mild	Mild	WNL	Mild	WNL	Mild	Mild
12	73	F	2	2.5	Mild	Mild	WNL	Mild	WNL	Mild	WNL
13	60	M	14	N/A	WNL	WNL	WNL	WNL	WNL	WNL	WNL

Note: Sex: M=Male, F=Female, Dur=disease duration (years), HY= Hoehn & Yahr stage (modified; Goetz et al., 2004), CLQT= Cognitive Linguistics Quick Test, CP= Composite Severity Rating, AN= Attention, ME= Memory, EX= Executive Functions, LG= Language, VS= Visuospatial, CD= Clock Drawing Severity Rating, WNL= Within Normal Limits

Inclusion/exclusion criteria

The inclusion and exclusion criteria are aligned with studies of individuals with idiopathic PD (Farhan et al., 2017). All participants had to have a diagnosis of PD by a neurologist as per self-report. A broad range of PD severities (mild-moderate) was accepted to reflect a comprehensive population. Participants demonstrated good comprehension skills and were able to answer yes/no questions reliably, follow simple and multi-step commands without much difficulty, and follow the general meaning of a conversation. Sufficient hearing ability was assessed using a hearing screen. All participants were native English speakers per self-report, had a negative history for progressive, deteriorating cognitive conditions such as Alzheimer's per self-report. For the PD participants, all but one person demonstrated no depression at the time of the experiment as measured by a score of 4 or higher on the Geriatric Depression Scale, Short Version (Sheikh & Yesavage, 1986).

Neuropsychological Testing

The CLQT was used to determine the relationship of general cognitive skills with accuracy on the RISC social perception task. The CLQT tests five different cognitive domains: attention, memory, language, executive functions, and visuospatial skills. The CLQT

tasks include symbol cancellation, personal facts, confrontation naming, generative naming, story retelling, clock drawing, design memory, symbol trails, design generation, and mazes. Each of these task's tests one of the five cognitive domains mentioned above (Parashos, Johnson, Erickson-Davis, & Wielinski, 2009).

Stimulus materials

Stimuli consisted of 96 video clips, ranging from 5 to 10 seconds in length. They were taken from the RISC database, an English-speaking collection of naturalistic video vignettes depicting social exchanges between two actors (Rothermich & Pell, 2015). In the videos, a mixed-sex couple, a male boss with his employee, female friends, and mixed-sex colleagues portray different relationships. However, since previous studies only revealed minimal effects of the type of relationship, we did not include this as a factor of interest in our analysis (Rothermich & Pell, 2015). Each video clip consisted of one actor/actress asking a question and another actor/actress responding to the question (see **Figure 1** for example screenshots). These responses can be either literal (literal positive, blunt) or nonliteral (sarcasm, teasing). For example, one actor/actress offers homemade cookies to the other actor/actress. The actor/actress who was offered a cookie replied with one of the following statements: a literal positive remark conveyed as a genuine pleasing opinion ("Mmm, they look good!"); a sarcastic response which was lexically identical to the literal positive remark but conveyed as a criticizing opinion ("Mmm, they look so good!" matched with a repulsive facial expression and/or tone); a literal negative (blunt) remark that was conveyed as a sincere unfavorable opinion ("Honestly, they don't look very appetizing"); or a teasing remark which was lexically similar to the blunt remark and conveyed an opposing opinion that is portrayed as positive ("Honestly, they don't look very appetizing," but pursues to giggle and picks up a cookie anyway; see **Figure 1**).

Importantly, the actors/actresses in the video use an array of prosodic cues, facial expressions, body language, and gestures to indicate their intentions. For example, when portraying sarcasm, actors often smirk, use eye rolling, or change their pitch to indicate a mocking intention. When portraying teasing, the actors often use laughter at the end of the statement to indicate that they do not really mean what they say.

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Figure 1 Screenshots of RISC video materials.

Procedure

The experiment was conducted using the Experiment Builder software by SR Research. We also collected concurrent eye tracking data for a companion study, however those results will not be reported here. Participants were seated in front of a 24" LED monitor with their eyes approximately 60 cm from the display. Each participant was presented with 96 videos from the RISC database. Following each video, participants were presented with a yes or no question such as "Was this response sincere?". Participants then indicated either yes or no by pressing a button. In order to minimize outside influences, the 96 videos were randomized into 4 counter-balanced lists. Participants were notified upon 50% completion and were offered a short break prior to completing the remaining trials.

Data analysis

The data was statistically analyzed using R (R Development Core Team, 2016) and linear mixed-effects (LME) using lme4 in R (Bates et al., 2013). To gauge post hoc p-values, we applied the Satterthwaite (1946) approximation, which is implemented in the lmerTest package version 2.0-6 (Kuznetsova et al., 2017). Distinctive LME models were established for the dependent variable accuracy (speaker belief). To test the models, we began by defining a base model with a maximum random effect structure (subject, item, and relationship). Models were then compared using the ANOVA function in R by adding fixed effects (see a similar approach in Valuch et al., 2015). Our fixed effects were Intention (literal positive, literal negative, sarcasm, jocularity) and group (PD, HC). Comparisons were based on χ^2 , Akaike information criterion (AIC; Hu, 2007), and p values. For post hoc comparisons we report β estimates, z values, and p values.

Results

Neuropsychology testing

For an overview of patient profiles, please see **Table 1**. Scores for the *CLQT* Attention Domain ranged from 68 to 209 of a possible of 215 points ($M = 160.31$) with eight of the 13 participants with PD scoring within normal limits (above 180 points for those below 70 years of age; above 160 points for those 70 and older), two scoring within the mild severity range (between 125-179 points for those below 70 years of age; between 100-159 for those 70 and older), and two within the moderate severity range (between 40-99 points for those below 70 years of age; between 100-159 for those 70 and older). Scores for the *CLQT* Memory Domain ranged from 142 to 185 of a possible of 185 points ($M = 158.46$), with 10 of the 13 participants with PD scoring within normal limits (above 155 for those below 70 years of age; above 141 for those age 70 and older) and three scoring within the mild severity range (between 141-154 points for those below 70 years of age; between 115-140 for those 70 and older). Scores for the *CLQT* Language Domain ranged from 29 to 37 of a possible of 37 points ($M = 32$), with 13 of the 13 participants with PD scoring within normal limits (above 29 for those below 70 years of age; above 28 for those age 70). Scores for the *CLQT* Visual Spatial Skills Domain ranged from 52 to 100 of a possible of 105 points ($M = 79.69$), with 9 of the 13 participants with PD scoring within normal limits (above 82 points for those below age 70; above 62 points for those age 70 and above) and 4 scoring within the mild severity range (between 52-81 points for those below 70 years of age; between 37-61 for those 70 and older). Scores for the *CLQT* Executive Function Domain ranged from 15 to 35 of a possible of 40 points ($M = 27.46$), with 11 of the 13 participants with PD scoring within normal limits (above 24 for those below 70 years of age; above 19 for those age 70) and scoring within the mild severity range (between 20-23 points for those below 70 years of age; between 14-18 points for those age 70 and older). Scores for the *CLQT* Clock Drawing ranged from 9 to 13 of a possible of 13 points ($M = 12.15$), with 12 of the 13 participants with PD scoring within normal limits (above 12 points for those below 70 years of age and 11-13 points for those age 70) and 1 scoring within the mild severity range (between 9-8 points for those below 70 years of age between 9-10 points for those age 70). Composite Scores for the *CLQT* ranged from 3.2 to 4 of a possible of 4 points ($M = 3.75$), with 9 of the 13 participants with PD scoring within normal limits (above 3.5 points) and 4 scoring within the mild severity range (i.e., between 2.5 and 3.4 points).

Sincerity task

Linear Mixed Models were used to compare accuracy scores for both groups and all four intentions (see **Figure 2**). In general, HCs ($M = 84.1$ % correct) performed slightly better than people with PD ($M = 79.6$ % correct). However, we did not find a significant main effect of group when comparing the base model ($AIC = 1881.7$) with the model containing group as a fixed factor ($AIC = 1882.5$, $\chi^2 = 1.169$, $p = 0.2796$).

Concerning differences between intentions, all participants performed best when identifying blunt interactions as sincere ($M = 92.6$ % correct), followed by sarcastic ($M = 86.1$ % correct), literal positive ($M = 85.3$ % correct), and teasing scenes ($M = 84.1$ % correct). We did find a main effect of intention when comparing the base model with the model containing intention as a fixed factor ($AIC = 1681.5$, $\chi^2 = 206.23$, $p < .0001$). Post-

hoc comparisons revealed significant accuracy differences between blunt and teasing ($\beta = 0.292$, $t = 13.576$, $p < .0001$), literal positive ($\beta = 0.072$, $t = 3.379$, $p = 0.0041$), and sarcastic exchanges ($\beta = 0.064$, $t = 3.013$, $p = 0.0139$). In addition, teasing accuracy differed significantly from accuracy for literal positive ($\beta = -0.219$, $t = -10.156$, $p < .0001$) and sarcastic interactions ($\beta = -0.227$, $t = -10.581$, $p < .0001$).

Figure 2. Violin plots and boxplots depicting mean accuracy scores for the speaker belief task by intention and group.

We also explored the hypothesis-driven possibility of an interaction between group and intention and compared the condition only model ($AIC = 1681.5$) with a model containing an interaction ($AIC = 1680.9$). This comparison yielded a marginal significant effect of $p = 0.0743$ ($\chi^2 = 8.520$). Hypothesis-driven post-hoc comparisons yielded no further significant comparisons.

Correlation results

Pearson correlations were used to analyze the relationship between the speaker belief task (accuracy in %) and five CLQT sub scores. We found a significant positive correlation between accuracy scores and attention ($R = 0.61$, $p = 0.0259$), memory ($R = 0.71$, $p = 0.0065$), executive function ($R = 0.57$, $p = 0.0422$), and visuo-spatial skills ($R = 0.72$, $p = 0.0058$). No significant correlations were found for language and clock drawing.

Discussion

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Understanding social-cognitive impairments in PD is critical because they are linked to dysfunctional social relationships, impaired communication skills, and a poorer quality of life (Van Uem et al., 2016). In the current study, we examined social perception abilities in people with PD and age-matched controls, as well as the relationship to general cognitive skills. All participants had greater difficulty identifying teasing compared to the other speaker intentions. Individuals with PD were less accurate in recognizing speaker belief compared to healthy controls (HC), possibly due to changes in cognitive abilities. We could only find a marginally significant effect of group, likely due to our small sample size. Our analyses also revealed significant correlations between accuracy in the speaker belief task and several cognitive domains.

All participants performed the speaker belief task more accurately for sincere and sarcastic statements, but they display difficulty accurately identifying teasing as insincere. This is in accordance with data published previously using videos from the RISC inventory (e.g., Jakobson et al., 2018; Joergensen et al., 2021; Rothermich et al., 2021a, Rothermich et al., 2021b) and other stimulus materials (e.g., Gibbs, 2000; Hancock, Dunham, & Purdy, 2000; Kreuz & Glucksberg, 1989; Kumon-Nakamura, Glucksberg, & Brown, 1995; Sperber, 1984). A reason for this difficulty identifying teasing could be the so-called “asymmetry of affect” (Clark & Gerrig, 1984), which refers to the asymmetric findings regarding the use and perception of sarcasm and teasing. It states that sarcasm generally occurs more frequently than teasing (Clark & Gerrig, 1984; Matthews et al., 2006; Sperber & Wilson, 1981) and there is additional data showing that sarcasm is often recognized earlier and more accurately compared to teasing (Caillies et al., 2019; Hancock et al., 2000; Harris & Pexman, 2003). The current data also provide corroborating evidence for the influence of aging on perceiving nonliteral language (Phillips et al., 2015; Pomareda et al., 2019). Both of these studies suggest that declines in ToM and emotion perception abilities contribute to the changes in nonliteral language perception along the life span. Future studies should explore how these factors interact with a decline in general cognitive skills.

Contrary to our hypothesis, we did not find a significant effect of group when analyzing speaker intention accuracy. However, there was a trend towards significance, so a larger sample size might reveal a significant effect. Previous studies have revealed mixed results when testing the inference of speaker intentions in PD (for recent reviews see Alonso-Recio et al., 2021; Coundouris et al., 2020; Palmeri et al., 2017; Seubert-Ravelo et al., 2021). While several studies revealed deficits in the ability to understand other people's intentions in PD (e.g., Bodden et al., 2010; Pell et al., 2014; Mimura, Oeda, & Kawamura, 2006; Tsuruya, Kobayakawa, & Kawamura, 2011), others were unsuccessful in finding differences between PD and HCs (Péron et al., 2009; Roca et al. 2010; Euteneuer et al., 2009). The novel PD-SC phenotype (Czernecki et al., 2021) might explain some of the discrepancies in earlier studies on social cognition impairments in PD. That is, prior experimental studies have not accounted for the presence of a social cognition phenotype in PD. As such it is possible that the subject-level heterogeneity observed across studies could result from having mixed cohorts of PD participants with and without a definable social cognition impairment. It is therefore crucial to conduct further studies on social cognition in PD and PD-SC in large cohorts.

Our statistical analyses for the PD group revealed significant positive correlations between several cognitive domains, such as attention and memory, and the performance on the social perception task. This is in accordance with previous studies showing a relationship between general cognitive skills and social cognition measures (Assogna et al., 2010; e.g., Esteves et al., 2018; McNamara & Durso, 2003; Narme et al., 2011). Using similar dynamic video stimuli in a previous study, we could show that limitations in working memory and frontal lobe function correlated with difficulties in social inference making in people with PD (Pell et al., 2014). Taken together with the current findings, this suggests that affective dysfunctions may occur independently from general cognitive deficits in people with PD. Yet, impairments in working memory, attention or executive functions often arise when task demands are very high (Argaud et al., 2018). Importantly, 20% of participants that were identified as having the PD-SC phenotype in the study by Czernecki and colleagues (2021) did not present with any general cognitive impairments. In our sample, the ratio of PD versus PD-SC patients is undetermined. More studies are needed to explore the relationship between social cognition and general cognitive skills in this new phenotype.

Limitations in this study include a small sample size due to limited participation opportunities because of the COVID-19 pandemic. Additionally, HC and PD participants were not tested in the same environment; however, the same tasks and videos were used for both groups, and HC and PD participants were matched for gender, age, and level of education to reduce variability between groups. Neuropsychology testing was completed with PD participants but was not completed with the HC group.

Conclusions

Most studies of social cognition and emotion deficits in PD utilize static stimuli, which lack important real-life context (e.g., Mattavelli et al., 2021). In the current study, we utilize dynamic, context-rich video stimuli to examine nonliteral language perception in people with PD and HCs. The cognitive profile of persons with PD was assessed with a neuropsychological battery. Our findings support a relationship between general cognitive abilities and perception of speaker intentions in PD. These findings help to generate new research hypotheses for eye tracking and neuroimaging studies, which will expand our knowledge of the neural underpinnings of social perception, and PD broadly. Our findings will also aid the development of targeted tools for diagnosing and treating social cognition impairments in PD.

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