Pragmatic abilities in Parkinson's disease and healthy aging

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XXXIV Cycle

1. Project overview

My research focuses on pragmatic language deficits in patients with Parkinson's disease and healthy older adults. The project is structured in three different phases. The first phase relates to the study of pragmatic abilities in patients with early Parkinson's disease, and this research was carried out during the first year of my PhD. The study is now completed and the manuscript has been submitted to a peer reviewed journal. The second phase coincides with the COVID-19 outbreak, during which I decided to change the initial project on Parkinson's disease due to lockdown restrictions. In fact, this second phase concerns the study of pragmatic skills in healthy older adults. The data collection has been converted to an online format and is still ongoing. A significant number of participants will be recruited by the end of November 2020. The third phase will hopefully start in January 2021 and foresees the development of the initial project on Parkinson's disease. Pragmatic abilities will be tested in patients with advanced Parkinson's disease; additionally, a metaphor comprehension paradigm will be implemented to test patients' ability to understand metaphors and its relationship with inhibitory control. Each phase of my research project will be now described in turn.

2. Background

2.1 Clinical Pragmatics

What is clinical pragmatics? Pragmatics can be defined as the study of language in context and concerns the interplay of linguistic content, contextual information and general rules in guiding communication (Grice, 1975). Clinical pragmatics explores the characterization, assessment and treatment of pragmatic disorders across the lifespan. A significant number of patients with impaired language skills also show deficits in the pragmatic domain. These patients belong to different clinical populations, such as autism spectrum disorder, adults with left and right hemisphere damage, schizophrenia, traumatic brain injury and neurodegenerative disorders. However, a decline of pragmatic skills has also been observed in healthy older adults (Rachel H. Messer, 2015). Overall, the impairment of pragmatic competence leads to an inappropriate and less efficient use of language.

Why do we need to study clinical pragmatics? Pragmatic impairment strongly impacts the way people communicate in social contexts. Deficits of both production and comprehension skills might be responsible of a reduction in social interaction and socialization due to the arise of communication difficulties. Consequently, the decreased engagement in social relationships leads to a poorer quality of life. Thus, it is crucial to detect pragmatic deficits as early as possible; additionally, the early identification of pragmatic impairment is essential to monitor its progression over time. Considering all these premises, it's of primary importance for clinical pragmatics to focus on a better characterization and understanding of pragmatic deficits, and to develop appropriate and comprehensive assessment tools.

Another reason to focus on pragmatic deficits relies in the investigation of the underlying mechanisms of pragmatic processing, since the existing evidence is still somehow conflicting. Pragmatic competence is traditionally considered in strict relation with the ability of attributing mental states to others, an inferential mechanism that is commonly referred to as Theory of mind – ToM (Brüne & Bodenstein, 2005). However, growing evidence show that pragmatic competence is not only related to ToM, but also to a cluster of cognitive functions, such as executive functions (e.g., working memory, inhibitory control, shifting etc.), that might differ across populations and pragmatic tasks (Bosco, Tirassa, & Gabbatore, 2018; Domaneschi & Bambini, 2020). Thus, pragmatic competence cannot be reduced to ToM abilities; conversely, it should be considered as a more complex phenomenon, whose cognitive underpinnings still need to be clarified.

2.2. Pragmatic Abilities

Pragmatic abilities refer to key conversational skills that allow speakers to use language appropriately according to different communicative situations (Louise Cummings, 2017). Some of these skills concern the ability to communicate appropriate amount of information in the proper social context, making appropriate requests and commands, knowing how start, conduct and end a conversation, making socially appropriate requests and providing thematically cohesive narratives of relevant events (McNamara & Durso, 2003). Pragmatics typically investigates verbal phenomena in which there's a gap between the literal and the communicative meaning: listeners therefore need to integrate contextual information in order to understand the speaker's intended meaning. Metaphors, irony and non-literal language in general are among the phenomena in which context plays a major role; however, there are also other important domains such as aspects of discourse (topic maintenance and coherence), in which speakers need to adhere to rules of appropriateness to context (Arcara & Bambini, 2016). However, this research field investigates several non-verbal behaviors as well, such as intonation, eye contact, facial expressions, gestures and proxemics, which all contribute to an effective and goal-oriented communication. Many studies shed light on the underlying mechanisms of pragmatic processing, which is traditionally considered in strict relation with ToM, i.e. the ability of attributing mental states to others (Brüne & Bodenstein, 2005b). The reason is that deriving the speaker's intended meaning involves the attribution of intentions to others (Sperber & Wilson, 2002). Despite pragmatics has been previously considered as a submodule of ToM (Sperber & Wilson, 2002), there is growing evidence showing that pragmatic competence cannot be limited to the ability to understand others' mental states and intentions, and therefore needs to be considered as a more complex phenomenon (Bosco et al., 2018). Thus, it is not possible to conclude that pragmatic abilities rely on ToM only (Domaneschi & Bambini, 2020), and this view is supported by recent findings showing that ToM alone cannot explain the performance of children (Bosco & Gabbatore, 2017a, 2017b) and patients with schizophrenia (Bosco, Angeleri, Zuffranieri, Bara, & Sacco, 2012) in different pragmatic tasks. Furthermore, another reason against the thesis of an overlap of ToM and pragmatics lies in the neural substrates and in the developmental and decay patterns of pragmatic competence, which are distinct from ToM (Domaneschi & Bambini, 2020). Growing interest has been also devoted to cognitive functions and, more specifically, to the possible relation between executive functions (i.e., a cluster of cognitive processes involved in goal-directed actions) and pragmatic processing. Thus, it is possible to conclude that pragmatic abilities might rely on ToM but also, sometimes more prominently, on clusters of cognitive functions (Martin I & McDonald S, 2003; Montemurro, Mondini, Signorini, Bambini, & Arcara, 2018).

3. Phase I

3.1 What we know

3.1.1 Parkinson's Disease

Parkinson's disease (PD) is a chronic, neurodegenerative disorder, which affects about 1% of the population aged 65 years and over . It is considered a movement disorder, characterized by the loss of dopaminergic neurons in the corpus striatum (Holtgraves & McNamara, 2010), which leads to several debilitating extrapyramidal motor dysfunctions (Pell & Monetta, 2008). The primary motor impairments associated with the disease include muscle rigidity, bradykinesia, resting tremor, and postural instability. However, several non-motor dysfunctions have been reported as well, such as mood alterations, sleeping problems, and cognitive changes (Monetta, Grindrod, & Pell, 2008). With regard to cognitive symptoms, they could be mild, thus not affecting everyday life, or more severe, leading to a clinically evident condition of dementia (Papagno & Trojano, 2018). To date, the impairment of executive functions has been well documented in PD patients, and it typically encompasses several domains, such as planning, shifting, inhibition, conflict resolution, decision making, and dual task performance (Papagno & Trojano, 2018). The strong connectivity of the striatum with cortical – mainly frontal and limbic – sites may also explain the vulnerability of many functions related to language and non-verbal communication in patients with PD (Papagno & Trojano, 2018; Pell & Monetta, 2008)

3.1.2 Pragmatic abilities in Parkinson's disease

Only a few studies investigated pragmatic abilities in PD and these suggest that pragmatic skills might be impaired; in fact, the available findings show that patients with PD display both language comprehension and production deficits (Thomas Holtgraves & Cadle, 2016).

Pragmatic production. Deficits for both verbal (conversational initiation, turn taking, topic maintenance, response length and referencing skills) and non-verbal (intonation, eye-contact, facial expressions, gestures, and proxemics) dimensions have been reported (Hall, Ouyang, Lonnquist, & Newcombe, 2011; Holtgraves, Fogle, & Marsh, 2013; Thomas Holtgraves & Cadle, 2016). Holtgraves and colleagues (2013) showed that patients with PD produce significantly more underinformative sentences compared to healthy participants. Furthermore, PD patients exhibited worse production skills in tasks targeting discourse organization, engagement in conversation, and the ability to produce informative descriptions of different pictures (Montemurro et al., 2018). In addition, it has been argued that patients with PD tend to produce syntactically simple language, as well as abnormalities in speech fluency such as prolonged and inappropriate pauses (Thomas Holtgraves & Cadle, 2016). Lastly, it has been suggested that production deficits might be linked to the severity of motor symptoms (Colman & Bastiaanse, 2011; Thomas Holtgraves & Cadle, 2016). In particular, Illes, Metter, Hanson, & Iritani, (1988) suggested that PDs' syntactically simple sentences may reflect a compensatory mechanism to reduce speech-motor difficulties.

Pragmatic comprehension. Comprehension seems to be compromised in PD patients as well (Holtgraves & Giordano, 2017), especially the understanding of figurative language, verbal irony and other implicit contents (Lewis, Lapointe, Murdoch, & Chenery, 1998; Monetta, Grindrod, & Pell, 2009a; Papagno & Trojano, 2018). For example, in a study by (Berg, Björnram, Hartelius, Laakso, & Johnels, 2003), PD patients exhibited difficulties in making inferences, understanding metaphors and lexical ambiguities. Additionally, Thaler et al., (2012) showed that PD patients have a significantly poorer sense of humour than control participants. In addition, Montemurro et al. (2018) tested PD patients' (and healthy controls) ability to understand a set of pragmatic phenomena such as narrative, humour and figurative language, and found that PD patients scored significantly lower in both the narrative and humour comprehension tasks.

Pragmatic abilities and cognitive functions. To date, some studies showed that changes in pragmatic abilities are often related to concomitant cognitive deficits (Colman & Bastiaanse, 2011; McNamara & Durso, 2003; Pell & Monetta, 2008). McNamara and Durso (2003) found a correlation between PD patients' compromised turn-taking abilities and disrupted frontal-lobe functioning (McNamara & Durso, 2003). Additionally, Holtgraves and colleagues (2013) showed that patients' ability to comprehend and produce informative utterances is related to executive control deficits (Holtgraves et al., 2013). In a study by Monetta & Pell (2007), PD patients with impaired working memory were also significantly slower and less accurate than healthy controls in processing metaphors, and similar findings have been shown in a follow up study on pragmatic inference generation (Monetta et al., 2008) and irony comprehension (Monetta, Grindrod, & Pell, 2009b). Furthermore, McKinlay et al. (2009) suggested that processing speed strongly influences PD patients' performance on a set of pragmatic tasks (McKinlay, Dalrymple-Alford, Grace, & Roger, 2009). Finally, with respect to the role of ToM in pragmatic abilities and ToM in PD, research is still very limited. To the best of our knowledge, the only available study is Vachon-Joannette, Tremblay, Langlois, Chantal, & Monetta (2013) that reported significant correlations between PD patients' metaphor comprehension and ToM abilities (Vachon-Joannette et al., 2013).

3.2 Open Issues

To date, a wealth of open issues cries out for further investigation.

First, most of the available studies enrolled PD patients whose symptom severity was highly heterogeneous, thus not focusing on a specific stage of the disease (McKinlay et al., 2009; McNamara & Durso, 2003; Montemurro et al., 2018). Crucially, a clear picture of pragmatic impairment in early PD patients is missing, as it is still uncertain if and how these skills are compromised at this stage.

Second, Montemurro et al. (2018) is the only study that targeted pragmatic abilities through a comprehensive assessment. In fact, they observed not only PD patients' difficulties in specific pragmatic tasks, but impairments in both general production and comprehension as well as, importantly, in general pragmatic abilities. However, in Montemurro et al. (2018), the sample of PD patients was not balanced in terms of the severity of the disease. Therefore, this does not allow to clearly characterize the onset of the pragmatic impairment.

Third, despite some authors suggested that the impairment of pragmatic abilities in PD might be due to a cognitive dysfunction, the existing evidence about this link is still somehow conflicting. Interestingly, Montemurro et al. (2018) found that Cognitive Reserve might have a compensatory effect on the decline of pragmatic abilities, paving the way to the possibility that cognitive (dys)function might play a role in the pragmatic impairment in PD. Thus, in order to investigate the relationship between pragmatic competence and cognitive skills, a comprehensive neuropsychological assessment including both screening batteries and domain-specific tests would be needed.

3.3 Aim of the Research

The present study has two main goals. First, to trace a comprehensive characterization of pragmatic abilities in early PD patients. Second, to investigate whether a pragmatic impairment in early PD might stem from emerging deficits of specific cognitive functions. If executive dysfunction is already visible at an early stage of the disease, then we expect to observe an early pragmatic impairment in those pragmatic phenomena whose processing relies more on faculties such as attention, inhibition, and working memory.

3.4 Methods

3.4.1 Participants

Eighteen early PD patients [mean age 69.77(5.87); mean years of education 11.38(3.39); mean Hoehn&Yahr 1.88(0.21); 4 F, 14 M] were recruited at the IRCCS San Martino Hospital (Genova, Italy). Patients were carefully selected by neurologists on the basis of the early stage of their disease (Hoehn & Yahr scores between 1.0 and – 2.0). The clinical evaluation of patients' PD stage was conducted according to the following procedure: disease severity was evaluated with the Hoehn and Yahr (H&Y; "Parkinson's Disease: Hoehn and Yahr Scale," 2012) and with Movement Disorders Society (MDS) - Unified Parkinson's Disease Rating Scale (UPDRS) part III (MDS UPDRS-III) (Antonini et al., 2013).

A sample of 21 healthy elders (ELD) matched as much as possible with the PD group [mean age 70.42(3.77); mean years of education 13.19(3.85); 12 F, 9 M] was recruited from the *Creative Mind Cafè,* an elderly community centre located in Genoa.

All participants were tested in a quiet room at the Department of Neuroscience (University of Genoa). All participants were Italian native speakers.

3.4.2 Procedure and materials

Participants were administered a set of measures, in the following order: (i) a survey that collected relevant demographic (age and education) and clinical information (duration of illness for the PD group, quantified as number of years from onset); (ii) the APACS test, *Assessment of Pragmatic Abilities and Cognitive Substrates* (Arcara & Bambini, 2016), to collect measures for their pragmatic competence; (iii) a battery of selected neuropsychological tests that included both screening batteries for cognitive assessment and domain-specific tests. The tests were administered in two separate experimental sessions (about 1-hour each), and they were administered in fixed order to control for fatigue and to reduce cognitive effort across tasks in each session.

3.4.2.1 Pragmatic assessment

Participants were assessed for their pragmatic abilities with the Assessment of Pragmatic Abilities and Cognitive Substrates (APACS; Arcara & Bambini, 2016), a standardized measure assessing both discourse production and comprehension by means of six tasks.

The APACS test consists of two sections: the first one assesses Pragmatic Production and is composed of two dedicated tasks; the second one evaluates Pragmatic Comprehension and is composed of four dedicated tasks. Three main composite scores are computed: a composite score for production, one for comprehension and a composite score for participants' overall performance in APACS (i.e., APACS Total).

Task 1: Interview (production). It is a semi-structured interview based on autobiographical topics that assesses discourse organization and engagement in conversation. It evaluates several dimensions of discourse, such as speech (e.g., repetition, echolalia, incomplete utterances), informativeness (over- or under-informativeness), information flow (missing referents, wrong order of the discourse elements, topic shift), and paralinguistic aspects (altered intonation, fixed facial expression, abuse of gestures, loss of eye-contact). For each type of communication deficit, the frequency of occurrence is collected (i.e., always/sometimes/never) and the correspondent score is assigned (i.e., 0/1/2). The maximal score is 44.

Task 2: Description (production). This task measures the ability to produce informative descriptions of 10 pictures that depict scenes of everyday life. Participants' production of salient elements for each picture is coded and this is scored as 0/1/2, with 0 indicating a missed identification, 1 a partially correct identification, and 2 a good identification. The maximal score for is 48.

Task 3: Narratives (comprehension). Participants are read six stories inspired by real newspapers. Each story is followed by: (i) one open question about the global topic of the story; (ii) 2-to-4 yes-no comprehension questions on explicit and implicit contents rated 1 when correctly answered, or 0 when incorrectly answered; (iii) 2 questions that elicit a verbal explanation of the 2 figurative expressions embedded in the story. Participants' answers to (i) are coded as 2 when the global topic is correctly identified, 1 when a partially correct identification of the global topic is provided, or 0 when the topic is not correctly identified. Participants' answers to (iii) are rated 2 if a good explanation is provided, 1 if participants provide an incomplete explanation or an example, or 0 if participants provide a literal explanation, a paraphrase or no explanation at all. The maximal score for is 56.

Task 4: Figurative language 1 (comprehension). This task provides a measure for the ability to infer non-literal meanings. Participants are first presented with idioms, novel metaphors and proverbs and they are asked multiple-choice questions for each item. Participants' accuracy is collected and coded as 0 or 1, depending on (in)correct response selection. The maximal score is 15.

Task 5: Humor (comprehension). The subtest measures the ability to comprehend verbal humor through a multiple-choice task. Participants are asked to pick the best punch line of a story. Accuracy is collected and scored as 0/1. The maximal score is 7.

Task 6: Figurative language 2 (comprehension). This is a second, more direct, measure for the ability to infer non-literal meanings. Participants are asked to explain the meaning of 15 figurative expressions (i.e., idioms, novel metaphors and proverbs) and their accuracy is collected. For each expression, the participants' explanation is scored 2 if a good description of the meaning of the figurative expression is provided, 1 if an incomplete explanation or an appropriate example is provided, or 0 if a literal explanation, a paraphrase or is provided or participants don't know the meaning of the expressions. The maximal total score is 30.

Composite scores and cut-off values. The Pragmatic Production composite score is obtained from the average of the sub-scores in *Interview* and *Description* transformed in proportion. The Pragmatic Comprehension composited score is computed from the average of the sub-scores in *Narratives*, *Figurative Language 1*, *Figurative Language 2*, and *Humour*, transformed in proportion. The APACS Total score is the average of the Pragmatic Production and Pragmatic Comprehension composite scores. In addition, PD patients' scores in each task are compared to cut-off values in order to identify any impaired pragmatic performance.

3.4.2.2 Neurocognitive assessment: screening batteries

Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005). This is a neuropsychological scale consisting of 8 subtests that assess: memory, language, visuo-spatial skills, executive functions, time and space orientation (see Appendix for details).

Parkinson's Disease-Cognitive Rating Scale (PD-CRS) (Santangelo, Barone, Abbruzzese, Ferini-Strambi, & Antonini, 2014). This neuropsychological scale consists of 9 subtests that assess: immediate free-recall verbal memory, confrontation naming test, sustained attention, working memory, unprompted drawing of a clock, copy drawing of a clock, delayed free-recall verbal memory, alternate verbal fluency and action verbal fluency. Three scores are obtained (subcortical, cortical and Total -see Appendix for details).

3.4.2.3 Neurocognitive assessment: domain specific tests

Digit Span forward and Digit Span backward (Spinnler & Tognoni, 1987). These measure short-term verbal memory and verbal working memory, respectively (see Appendix for details).

Corsi Span forward and Corsi Span backward (Spinnler & Tognoni, 1987). These tests measure short-term visuo-spatial memory and visuo-spatial working memory, respectively (see Appendix for details).

Verbal fluency test (Novelli et al., 1986)*(Novelli et al., 1986).* This test assesses both semantic and phonemic fluency (see Appendix for details).

Trail Making Test (TMT). This assesses set-shifting (see Appendix for details).

Stroop test (short version) (Venneri et al., 1992) This test measures inhibition and cognitive control (see Appendix for details).

"Valutazione delle capacità di costruzione dello scheletro" (Semantic Memory 1 task) and*"Denominazione visiva"* (Semantic Memory 2 task) (Sartori & Job, 1988). These tasks measure semantic memory (see Appendix for details).

Emotion Attribution Test (EAT) (Blair, 2000; Prior, Marchi, & Sartori, 2003) and *Reading the Mind in the Eyes test (RMEt)* (Vellante et al., 2013). These tests both measure affective ToM (see Appendix for details).

Advanced ToM Task (Blair, 2000; Happé, 1994; Prior et al., 2003). This assesses double bluff, white lies and persuasion (see Appendix for details).

Beck Depression Inventory II (BDI-II) (Beck, Steer, & Brown, 1996). It is a 21-item self-report inventory designed to assess the presence and severity of depressive symptoms (see Appendix for details).

3.5 Data analysis

First, group differences on APACS as well as on participants' scores in the battery of neuropsychological tests were analysed using the Wilcoxon Rank Sum Test. This analysis was conducted on each of the APACS tasks as well as on each of the three composite scores. Group differences were analysed for each of the neuropsychological tests, as well as for ToM and depression measures. Participants' individual performance was also analysed by comparing each participant's scores in APACS to the cut-off values.

Second, for each of the two groups of participants, pairwise Pearson's correlations were conducted to assess the relationship between participants' scores in each of the APACS tasks and composite scores and their performance in each of the neurocognitive measures, including ToM and depression measures.

Third, a stepwise multiple regression analysis was performed separately for PD patients and healthy controls to investigate which – if any – of the collected neurocognitive measures significantly predicts pragmatic performance. Given the high number of neurocognitive variables, predictors were first selected based on their significant correlation with the APACS measures. Starting from this procedure, some of the selected neurocognitive variables have been excluded later to prevent the models to be affected by multicollinearity. The final models included the following predictors: age, education, sex, MDS UPDRS-III (for the PD group only), the Stroop performance, and the PD-CRS Total score. This selection is also consistent with the existing literature on pragmatic abilities. In fact, the severity of motor symptoms, a general measure of cognitive skills, inhibition, cognitive control and other relevant demographic variables have been previously linked to pragmatic skills in patients with PD (Colman & Bastiaanse, 2011; Holtgraves et al., 2013). Given the exploratory nature of these analyses and the absence of previous experimental evidence on the same topic, a backward method based on AIC values was applied to determine the influence of each predictor within each model. Multicollinearity (VIF and mean VIF) and auto-correlation (Durbin-Watson test) diagnostics were carried out for each of the models. This analysis was performed for each of the three APACS composite scores and each of the sub-scores.

3.6 Results

3.6.1 Between-group analyses (APACS)

Patients with PD scored significantly lower than controls in the APACS Total score (p=0.004), Pragmatic Production (p=0.013), Pragmatic Comprehension (p=0.032), the Interview (p<0.001) and Figurative Language 2 (p=0.003) tasks. No significant differences emerged between patients and healthy elders in the Description, Narratives, Figurative Language 1 and Humor tasks.

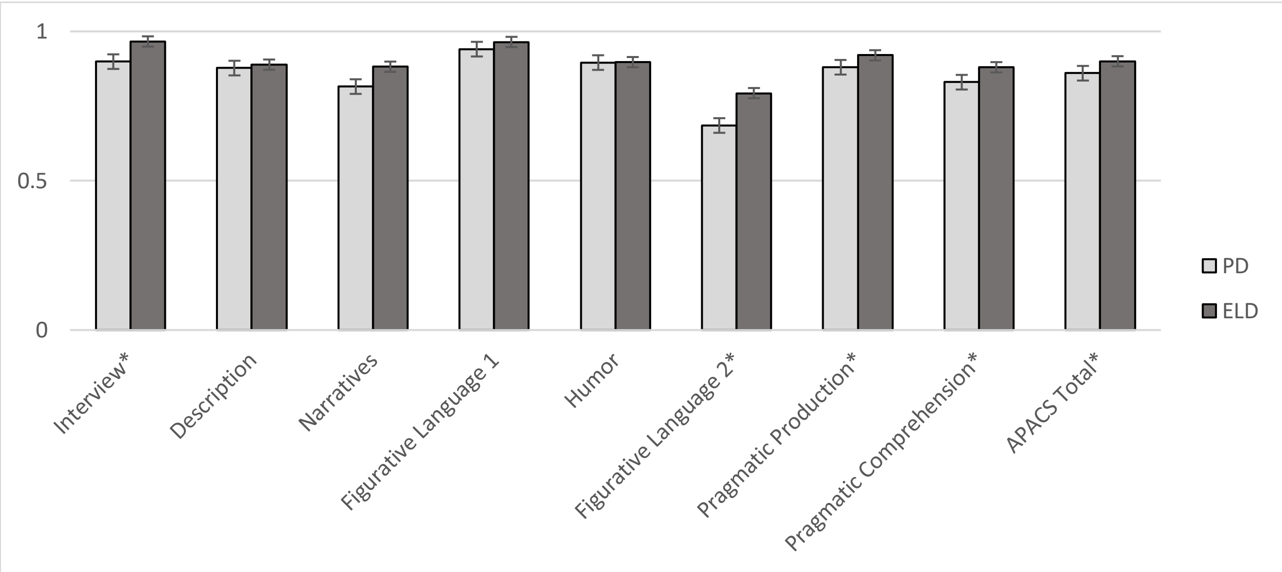

Figure 1. Mean proportional scores in each of the APACS tasks (Interview, Description, Narratives, Figurative Language 1, Humor and Figurative Language 2) as well as in the 3 composite scores (Pragmatic Production, Pragmatic Comprehension and APACS Total) for PD and ELD participants.

3.6.2 Between-group analyses (neurocognitive measures)

Patients with PD scored significantly lower scores than controls in the *Corsi Span backward* version (p=0.011), the time interference effect of the *Stroop* test (p=0.05), the *Trial Making* test (p=0.045), the *Semantic Memory 1* task (p=0.023) and some of the PD-CRS tasks (working memory -p=0.004; alternate fluency -p=0.004; action fluency -p=0.01) as well as composite scores (PD-CRS subcortical -p=0.003; Total score -p=0.004). No significant between-group difference emerged in the BDI-II scale.

3.6.3 PD patients' individual performance in APACS

At the individual level, a considerable number of patients showed a performance below cut off in the production tasks and composite score (number of patients below cut-off/total number of patients: *Interview task*: 12/18; *Description task* 13/18; *Pragmatic Production* 16/18). Furthermore, several patients also showed an impaired performance in two of the comprehension tasks and in the comprehension composite score (*Narratives task*: 10/18; *Figurative Language 2 task*: 9/18; *Pragmatic Comprehension*: 6/18). Similarly, a consistent number of PD patients obtained an impaired performance in the *APACS Total score* (11/18).

3.6.4 Correlational analysis (PD group)

APACS	Interview	Description	Narratives	Figurative Language 1	Humor	Figurative Language 2	Pragmatic Production	Pragmatic Comprehension	APACS Total
Age	0.08	-0.3	-0.49*	-0.2	-0.26	-0.45	-0.15	-0.49*	-0.49*
Education	-0.47*	-0.38	0.42	0.13	0.47*	0.5*	-0.49*	0.56*	0.2
Sex	0.2	0.21	0.024	0.23	-0.13	0.18	0.23	0.05	0.16
UPDRS III	-0.48*	-0.38	0.013	0.19	0.09	0.06	-0.50*	0.1	-0.18
Years from Onset	-0.17	0.2	0.064	0	-0.041	0.28	0.04	0.1	0.1
Digit Span_forward	0.46	0.3	0.15	0.25	-0.1	0.25	0.44	0.13	0.34
Digit Span_backward	-0.1	-0.1	0.05	0.21	0.18	-0.054	-0.12	0.12	0.035
Phonemic fluency	0.35	0.15	0.38	0.17	-0.07	0.19	0.28	0.2	0.32
Semantic fluency	0.1	0.53*	0.29	0.11	-0.027	0.21	0.41	0.19	0.37
Corsi_forward	0.13	0.05	0.44	-0.24	0.45	0.44	0.1	0.48*	0.45
Corsi backward	-0.28	-0.002	0.17	-0.3	0.23	-0.02	-0.14	0.11	0.02
BDI-II	-0.34	-0.34	-0.019	-0.09	0.04	-0.26	-0.4	-0.09	-0.28
Stroop accuracy	-0.1	-0.57*	-0.12	0.005	0.31	-0.03	-0.42	0.08	-0.15
Stroop time	-0.28	-0.17	-0.26	0.19	-0.31	-0.04	-0.26	-0.22	-0.32
TMT	-0.61**	-0.48*	0.03	-0.04	0.024	0.013	-0.63**	0.02	-0.32
PD-CRS working memory	0.34	0.18	0.41	0.11	0.11	0.4	0.29	0.36	0.45
PD-CRS total	0.57*	0.7**	0.29	0.17	-0.046	0.11	0.77**	0.15	0.53*
Semantic memory 1	0.06	-0.12	-0.13	0.04	-0.42	0.21	-0.03	-0.15	-0.15
Semantic memory 2	-0.008	0.31	0.2	-0.02	-0.26	0.09	0.16	-0.015	0.065
RTME	0.29	0.14	0.27	-0.13	-0.013	0.1	0.24	0.11	0.22
EAT	0.41	0.58*	-0.009	-0.08	-0.26	0.004	0.6*	-0.12	0.21
Advanced ToM	0.1	0.14	0.078	0.02	-0.036	0.05	0.15	0.035	0.11

Table 3A. Person Correlation coefficients in patients with PD (A) between APACS tasks and the other clinical, demographic and neurocognitive variables. Asterisks indicate significant correlations: ** $p<0.01$, * $p<0.05$.

3.6.5 Correlational analysis (ELD group)

APACS	Interview	Description	Narratives	Figurative Language 1	Humor	Figurative Language 2	Pragmatic Production	Pragmatic Comprehension	APACS Total
Age	-0.05	-0.05	-0.06	0.2	0.005	0.28	-0.06	0.11	0.05
Education	-0.33	0.15	0.44*	0.12	0.17	0.42	0.04	0.39	0.28
Sex	-0.02	-0.09	-0.05	0.12	-0.21	0.1	-0.09	-0.15	-0.14
Digit Span_forward	-0.42	-0.28	-0.24	-0.13	0.11	-0.03	-0.37	-0.05	-0.2
Digit Span_backward	-0.23	-0.09	-0.1	-0.002	0.3	0.32	-0.15	0.23	0.09
Phonemic fluency	0.23	0.005	-0.19	0.12	0.21	0.26	0.07	0.15	0.13
Semantic fluency	0.26	0.28	0.17	0.19	0.31	0.19	0.32	0.32	0.36
Corsi_forward	0.09	0.02	0.05	0.12	0.34	0.002	0.04	0.21	0.16
Corsi_backward	0.07	0.06	-0.3	-0.02	0.14	-0.13	0.07	-0.07	-0.01
BDI-II	0.06	0.17	-0.096	0.29	0.11	0.095	0.17	0.11	0.15
Stroop accuracy	0.01	-0.75**	-0.78**	-0.58**	-0.61**	-0.32	-0.66**	-0.78**	-0.82**
Stroop time	-0.23	-0.33	-0.42*	-0.27	-0.25	-0.36	-0.36	-0.43*	-0.45*
TMT	-0.54*	-0.18	-0.03	0.17	-0.11	0.17	-0.31	0.02	-0.12
PD-CRS working memory	-0.27	0.11	0.28	0.08	0.08	0.21	0.02	0.19	0.14

PD-CRS total	0.33	0.26	0.13	0.2	0.15	-0.01	0.32	0.15	0.24
Semantic memory 1	-0.31	0.21	0.26	0.09	-0.01	0.04	0.1	0.1	0.12
Semantic memory 2	-0.13	0.26	0.29	-0.29	-0.12	-0.17	0.2	-0.065	0.043
RTME	0.22	0.1	-0.03	0.16	-0.08	-0.21	0.15	-0.09	0.006
EAT	-0.5*	0.09	0.42	-0.11	0.01	-0.08	-0.05	0.1	0.04
Advanced ToM	0.17	0	0.28	0.03	0.18	0.03	0.05	0.2	0.15

Table 3B. Correlations in healthy controls between APACS tasks and the other clinical, demographic and neurocognitive variables. Asterisks indicate significant correlations: ** p<0.01, * p<0.05.

3.6.6 Analyses of predictors (PD group)

a. Predictors of APACS Total

Adjusted R^2	p	mean VIF	Test for autocorrelation	
			D-W	p
0.61	0.013	2.30	2.76	0.068

Predictor	Estimate	β_i	p	VIF
(Intercept)	0.63		0.0097**	
Stroop_time	-0.002	-0.43	0.11	2.32
PD-CRS Total	0.0037	0.89	0.008**	2.63
age	-0.002	-0.25	0.19	1.21
education	0.013	0.85	0.012*	2.77
sex	-0.073	-0.53	0.074	2.56

b. Predictors of APACS Pragmatic Production

Adjusted R^2	p	mean VIF	Test for autocorrelation	
			D-W	p
0.70	0.002	1.50	1.91	0.8

Predictor	Estimate	β_i	p	VIF
(Intercept)	0.65		<0.001**	
Stroop_accuracy	-0.006	-0.26	0.11	1.14
Stroop_time	-0.0016	-0.26	0.17	1.56
PD-CRS Total	0.003	0.73	0.0036**	1.81
sex	-0.048	-0.33	0.085	1.41

c. Predictors of APACS Pragmatic Comprehension

Adjusted R^2	p	mean VIF	Test for autocorrelation	
			D-W	p
0.54	0.0086	1.26	2.63	0.126

Predictor	Estimate	β_i	p	VIF
(Intercept)	0.76		0.034*	

PD-CRS Total	0.0024	0.35	0.11	1.36
age	-0.0053	-0.36	0.087	1.13
education	0.017	1.30	0.007**	1.30

d. Predictors of APACS Interview task

Adjusted R^2	p	mean VIF	Test for autocorrelation	
			D-W	p
0.42	0.014	1.12	1.38	0.22

Predictor	Estimate	β_i	p	VIF
(Intercept)	45.98		<0.001**	
Stroop_time	-0.15	-0.56	0.02*	1.12
MDS UPDRS III	-0.1	-0.28	0.21	1.12

e. Predictors of APACS Description task

Adjusted R^2	p	mean VIF	Test for autocorrelation	
			D-W	p
0.71	0.0006	1.35	2.15	0.82

Predictor	Estimate	β_i	p	VIF
(Intercept)	23.81		<0.001**	
Stroop_accuracy	-0.69	-0.46	0.009**	1.09
PD-CRS Total	0.22	0.76	0.001**	1.51
sex	-3.09	-0.32	0.08	1.45

f. Predictors of APACS Figurative Language 2 task

Adjusted R^2	p	mean VIF	Test for autocorrelation	
			D-W	p
0.78	0.0012	2.30	1.70	0.59

Predictor	Estimate	β_i	p	VIF
(Intercept)	12.8		0.23	
Stroop_time	-0.32	-0.78	0.0025**	2.32
PD-CRS Total	0.14	0.51	0.032*	2.63
age	-0.12	-0.20	0.17	1.21
education	1.39	1.27	0.00017**	2.77
sex	-5.90	-0.62	0.012*	2.56

Table 1 (a-f). Predictors of pragmatic abilities in the PD group. Asterisks indicate significant predictors: ** p<0.01, * p<0.05.

3.6.7 Analyses of predictors (ELD group)

a. Predictors of APACS Total

Adjusted R^2	p	mean VIF	Test for autocorrelation	
			D-W	p
0.69	<0.0001	1	1.96	0.83

Predictor	Estimate	β_i	p	VIF
(Intercept)	0.78		<0.0001**	
Stroop_accuracy	-0.08	-0.81	<0.0001**	1
PD-CRS Total	0.001	0.18	0.18	1

b. Predictors of APACS Pragmatic Production

Adjusted R^2	p	Test for autocorrelation	
		D-W	p
0.46	0.0027	1.89	0.74

Predictor	Estimate	β_i	p	VIF
(Intercept)	0.75		<0.0001**	
Stroop_accuracy	-0.05	-0.64	0.002**	1
PD-CRS Total	0.0015	0.27	0.13	1

c. Predictors of APACS Pragmatic Comprehension

Adjusted R^2	p	Test for autocorrelation	
		D-W	p
0.62	<0.0001	2.35	0.47

Predictor	Estimate	β_i	p
(Intercept)	0.9		<0.0001**
Stroop_accuracy	-0.1	-0.8	<0.0001**

d. Predictors of APACS Description task

Adjusted R^2	p	Test for autocorrelation	
		D-W	p
0.54	0.0002	1.8	0.63

Predictor	Estimate	β_i	p
(Intercept)	43.52		<0.0001**
Stroop_accuracy	-5.48	-0.75	0.0002**

e. Predictors of APACS Narratives task

Adjusted R^2	p	Test for autocorrelation	
		D-W	p
0.61	<0.0001	2.16	0.75

Predictor	Estimate	β_i	p
(Intercept)	51.01		<0.0001**
Stroop_accuracy	-7.54	-0.79	<0.0001**

f. Predictors of APACS Figurative Language 1 task

Adjusted R^2	p	Test for autocorrelation	
		D-W	p
0.29	0.0089	1.32	0.096

Predictor	Estimate	β_i	p
(Intercept)	14.59		<0.0001**
Stroop_accuracy	-0.82	-0.58	0.0089**

g. Predictors of APACS Humor task

Adjusted R^2	p	Test for autocorrelation	
		D-W	p
0.34	0.0047	2.19	0.73

Predictor	Estimate	β_i	p
(Intercept)	6.51		<0.0001**
Stroop_accuracy	-1.2	-0.61	0.0047**

h. Predictors of APACS Figurative Language 2 task

Adjusted R^2	p	Test for autocorrelation	
		D-W	p
0.22	0.024	2.6	0.17

Predictor	Estimate	β_i	p
(Intercept)	24.63		<0.0001**
Stroop_accuracy	-2	-0.51	0.024*

Table 2 (a-h). Predictors of pragmatic abilities in the ELD group. Asterisks indicate significant predictors: ** p<0.01, * p<0.05.

3.7 Discussion

Between-group differences in pragmatic skills. Patients with early PD show worse general pragmatic abilities as compared to healthy elderly in both the comprehension and production modalities. At the individual level, 61% of the patients scored below cut-off in the APACS Total, the Pragmatic Production composite score was below cut-off for 88% of patients, and for 33.3% of them Pragmatic Comprehension was impaired as well. These results are consistent with Montemurro and colleagues (2018), who also found compromised performance in the three APACS composite scores in the sample of patients with PD, compared to healthy controls. With respect to the simple APACS tasks, patients with PD achieved significant lower scores in the Interview and the Figurative Language 2 tasks, as compared to healthy controls. At the individual level, 66.6% of patients performed below cut-off in the Interview task, and half of the PD sample was actually impaired in the Figurative Language 2 task. Interestingly, no significant between-group difference in the Figurative Language 1 task emerged, while this was the case for the Figurative Language 2 task. Despite both tasks assess the ability to understand non-literal uses of language, they are carried out with different modalities. The first one is simple enough to reduce cognitive effort, since it consists of multiple-choice questions and only requires participants to select the correct interpretation out of three possible options. On the contrary, the second task is more cognitive demanding and also more ecological, as it assesses comprehension by asking the participants to orally paraphrase non-literal expressions; therefore, it taps on a more genuine understanding of the expression, as participants are required to autonomously derive the appropriate non-literal meaning. Overall, these results suggest that pragmatic skills are already impaired at the early stage of the disease, in both the production and comprehension dimensions, and this is the first study showing a deficit of pragmatic skills in a sample of patients with early-course PD.

Between-group differences in neuropsychological measures. Patients with PD obtained a worse performance in visuo-spatial working memory, inhibition, set-shifting and cognitive flexibility, verbal working memory, alternate and action fluency, and semantic memory. The total score of the PD-CRS suggested that PD patients show an impairment in general cognitive skills as compared to healthy controls, consistently with previous studies (McKinlay et al., 2009; Papagno & Trojano, 2018). Interestingly, we did not find any significant difference at the group level in any of the administered ToM tasks, and this might be due to the early stage of the disease. In fact, a previous study by Péron and colleagues (2009) showed that early PD patients' ToM performance did not significantly differ from that of healthy participants, and no significant difference between medicated and unmedicated patients emerged in the early PD group. In sum, these findings suggest that the mind-reading ability is still intact in both its affective and cognitive components in patients with early-course PD. Interestingly, this seems to suggest that the observed pragmatic impairment does not result from impaired ToM, and that other cognitive functions might be responsible for pragmatic impairment in early PD.

Predictors of pragmatic abilities. Different patterns of predictors emerged in the two groups. Within the PD group, patients with better general cognitive skills and higher education levels scored higher in the APACS Total, consistently with earlier research linking cognitive skills to pragmatic competence (Colman & Bastiaanse, 2011; Holtgraves et al., 2013) and showing that pragmatic skills are less efficient in people with lower education (Zanini, Bryan, De Luca, & Bava, 2005). Additionally, as for PD patients' production abilities, good general cognitive skills significantly predicted the Pragmatic Production composite score and the

Description task, while the latter and the Interview task were also predicted by good inhibitory control, consistently with previous research (Holtgraves et al., 2013). Importantly, different results emerged in the group of healthy participants. In this population, inhibitory control (i.e., the error interference effect of the Stroop test) was the only predictor of both general pragmatic abilities and Pragmatic Production. More specifically, participants who were more accurate in this test scored higher in most of the APACS tasks. Taken together, these findings suggest that inhibitory control plays an important role in performing different pragmatic tasks in both groups; however, intact general cognitive skills and higher education might act as compensatory mechanisms, supporting PD patients' general pragmatic competence and production abilities. Overall, despite the importance of unimpaired cognitive skills and high education levels, we believe that other factors might support PD patients' pragmatic performance, as reported by previous literature (Colman & Bastiaanse, 2011), and this represents an interesting starting point for future investigation targeting more advanced stages of the disease. As for pragmatic comprehension, the only significant predictor of healthy controls' performance in these two measures was accuracy in the Stroop task. On the contrary, interestingly, a substantially different pattern of results emerged in the group of PD patients. Within this group, general pragmatic comprehension was significantly predicted by education only. Even more interesting, inhibitory control (the time interference effect), general cognitive skills and education significantly predicted patients' performance in the Figurative Language 2 task. This finding suggests that inhibitory control predicts figurative language comprehension in early-course PD. However, the role of inhibitory control has been previously addressed in experiments on young healthy adults' interpretation of novel metaphors and idioms (Carriedo et al., 2016). In fact, it might be essential to suppress those properties of the metaphor literal meaning that are not essential to derive the metaphorical interpretation. Some studies have shown that the literal meaning of the expression is activated during early processing of novel metaphors, and that it is suppressed later on (Rubio Fernández, 2007; Weiland, Bambini, & Schumacher, 2014). It has been shown that the irrelevant properties of the literal meaning of the metaphor vehicle (e.g., 'Some hairstyles are bushes') are suppressed during metaphor interpretation and this has been associated with the role of inhibitory control (e.g., Glucksberg et al., 2001). The main idea behind these studies is consistent with a direct access view of metaphor interpretation (e.g., Gibbs, 1994; Wilson & Carston, 2007). According to this broad view, metaphorical meaning is accessed directly in online processing and the interpretation of literal meaning does not play any special role apart from providing a hint for the derivation of the metaphor. Thus, the literal meaning would be involved in the interpretive process only to the extent that the relevant literal properties of the metaphor vehicle (e.g., bushes are MESSY) are pragmatically adjusted such that they can be meaningfully exploited to derive the metaphorical meaning. On the contrary, the irrelevant properties of the vehicle literal meaning (e.g., bushes are GREEN) would not be used in the interpretive process and, after an initial activation, they would be readily suppressed. Therefore, it is reasonable that patients with better inhibitory skills exhibited a better interpretation of novel metaphors because they might have been more efficient in suppressing the irrelevant literal properties. As for idioms, the role of inhibitory mechanisms has been called for also with respect to this figurative use of language (Cacciari, Corrardini, & Ferlazzo, 2018; Galinsky & Glucksberg, 2000). Some studies on idioms processing suggest that a momentary activation of at least part of the literal meaning of the words that compose the idiomatic expression occur during idioms interpretation (e.g., Cacciari, Padovani, & Corradini, 2007; Holsinger & Kaiser, 2013). Futhermore, according to

Cacciari et al. (2018), suppression mechanisms of the literal meaning of the words that compose idiomatic expressions may take place and the activation of the literal meaning may depend on some psycholinguistic factors, such as the predictability of the expression. During the processing of predictable idioms, such as *My brother is always broke,* the literal meaning of the constituent words that appear first in the expression might suffice to pre-activate the constituent words that are more likely to appear next - in virtue of the predictability of the whole idiomatic expression. Once the activated literal interpretation becomes irrelevant for the idiomatic meaning, the literal meaning is actively suppressed. Therefore, based on this, our results suggest that idioms comprehension is impaired already in early-course PD. Yet, more efficient inhibitory skills still might facilitate idioms comprehension too. As for the role of education, PD participants with higher education showed less impaired comprehension abilities. Education is notably known as a socio-demographic factor that positively impacts individuals' cognitive reserve, thus acting as a protective factor (e.g., Da Silva et al., 2015). In addition, old adults with higher education were found to exhibit better metaphor understanding (Champagne-Lavau, Monetta, & Moreau, 2012) and socio-demographic factors were recently posited to influence individuals' metaphor comprehension (Gibbs & Colston, 2012). In light of this, therefore, it might be the case that education acts as a protective factor in PD pragmatic comprehension skills too, including the ability to understand non-literal meaning.

4. Phase II

4.1 COVID-19 pandemic

The outbreak of COVID-19 had a strong impact on my research project. In January 2020, I started a new data collection to test the relationship between pragmatic competence and non-motor symptoms in patients with PD. However, I didn't have the time to recruit enough patients due to the COVID-19 outbreak, and the ongoing experimental sessions were then interrupted. Additionally, we scheduled the beginning of another data collection with advanced PD patients for late March 2020 but, for the same reason, I wasn't able to start. The uncertainty about the end of the emergency and the vulnerability of older patients to the coronavirus disease have raised the issue of finding a good alternative to the original project on Parkinson's disease. First, I decided to change the population target, which shifted from older adults with a clinical condition to normal aging. Second, I chose to modify the data collection format due to the lockdown restrictions, opting for an online setting; this way, participants use their own computer to perform the selected tasks and thus can be tested from home. Some of the selected tests (i.e., the APACS test, the Digit Span and the Mini Mental State Examination) can be easily administered during a Skype session with each participant, while other measures (such as the Cognitive Reserve Index and the ToM task) have now been converted to online surveys. However, some other tests such as the Stroop task and the Corsi in their original versions cannot be administered online. The web-based application Psytoolkit allowed for the creation of an appropriate online version of both these tasks, which can be easily accessed through a link and performed by participants at home, under the supervision of the experimenter during the Skype session. However, only participants with good digital and computer skills can be enrolled, and this represents the main limitation of the online data collection. Furthermore, the online versions of the Stroop and the Corsi tests are not suitable for participants with motor disabilities (such as in the case of PD patients), which might prevent them to use the mouse and the keyboard effectively. Overall, this format seems to be particularly useful when testing healthy older adults. However, I hope I will be able to develop and complete the original project next year, since the first study raised new interesting questions about the progression of pragmatic disorders in advance stages of PD. If possible, data collection with PD patients will start at the beginning of January 2021.

4.2 What we know

4.2.1 Aging

During the course of normal aging, the body undergoes several significant changes encompassing the physical, cognitive and behavioural dimensions. Age-related cognitive decline is well-documented in the literature, and the most relevant findings show that working memory, attentional control, as well as processing speed are often affected as we age (Titone, Prentice, & Wingfield, 2000). A decreased working memory capacity is often common in older adults, as well as a decline of inhibitory control, which leads to a difficulty in suppressing the irrelevant information and the appropriate behavioral response. Additionally, attentional processes have been reported to be affected by aging, resulting in more time and a greater cognitive effort required to process information and to focus on relevant stimuli. Language difficulties have been documented by the existing literature, and some of the available studies reported an age-related decline of pragmatic abilities as well (Rachel H. Messer, 2015). In fact, an effective communication in reached through the combination of intact cognitive skills with good speech and language processing. The degree to which aging affects pragmatic abilities might vary by person, with some people showing more severe deficits compared to others.

4.2.2 Pragmatic abilities in aging

Deficits for both pragmatic production and comprehension abilities have been documented in normal aging.

Pragmatic production. Previous studies suggested that verbal, paralinguistic and non-verbal skills might be impaired. In fact, earlier research showed that older adults often exhibit difficulties with turn-taking due to attentional demands that might increase between turns, as well as when multiple speakers take part in the conversation. Additionally, changes in vocal quality often occur with aging, and prosody seems to be affected too (Prutting & Kirchner, 1987). Interestingly, some authors suggested that gestures are often ignored by older adults during conversations and, in turn, they tend to use fewer gestures to complement their speech (Cocks, Morgan, & Kita, 2011). Furthermore, research targeting other non verbal aspects such as eye gaze showed an age-related decline of eye gaze cues, and this is particularly evident in those situations in which an individual is encouraged by the conversation partner to look at something specific in the environment (Slessor, Phillips, & Bull, 2008).

Pragmatic comprehension. An impairment of pragmatic comprehension emerged in previous studies as well, especially the age-related decline of the ability to understand figurative language (Mashal, Gavrieli, & Kavé, 2011; Rachel H. Messer, 2015). A study by Vogel and colleagues showed that older adults exhibited more difficulties in the explanation of idioms compared to their younger counterpart. Additionally, Qualls and colleagues identified a decline of the ability to interpret proverbs during normal aging, in line with previous findings showing impaired proverb comprehension in older participants (Uekermann, Thoma, & Daum, 2008), especially when this skill is assessed with an open format (Nippold, Uhden, & Schwarz, 1997). However, as for figurative language understanding, familiarity might play a crucial role (Qualls & Harris, 2003). In fact, some authors suggested that older people have more difficulties in interpreting proverbs, as compared to idioms, since the latter are already stored in our memory and therefore lexicalized. In another study targeting metaphor comprehension, two groups of participants (younger vs older adults) underwent two different tasks: first, they were asked to decide whether the presented two-word expressions were metaphorically plausible, literally plausible, or unrelated, and second, to rate the familiarity level of a set of two-word metaphorical expressions. Relative to young participants, older adults rated fewer expressions as metaphorically plausible. As for the familiarity rating task, the group of elderly was found to appreciate more metaphorical expressions as conventional, as compared to younger participants. The results showed that novelty plays a crucial role in the appreciation of the plausibility of semantic relationships, and the authors suggested the existence of age-related differences in the comprehension of novel vs conventional metaphors (Mashal et al., 2011). However, the available evidence on metaphor comprehension in aging is still somehow conflicting, since some other studies showed that metaphor comprehension abilities seem to remain intact in older adults (Light et al., 1993). With respect to humor comprehension, interesting findings emerged in previous literature. In fact, some studies showed that older adults tend to make more errors compared to young participants in selecting funny endings of jokes (Mak & Carpenter, 2007; Uekermann, Channon, & Daum, 2006). Schaier and Cicirelli (1976) tested three groups of older adults (age 50-59, 60-69, and 70-79), who were asked to rate the funniness of the selected jokes, and then to explain what was funny about those jokes, considering explanation as a proxy of comprehension. Results showed a significant age-related decline of humor comprehension and a significant correlation between humor appreciation and age. Consistently with these findings, a more recent study comparing two groups of old adults (age 60-70 and 71-90) showed that the second group, in which older participants were enrolled, exhibited more difficulties than the first group in selecting the correct ending of humorous stories (Daniluk & Borkowska, 2017).

Pragmatic abilities and cognitive functions. Several important factors need to be taken into account when considering pragmatic language changes in aging. In fact, most of the well-documented difficulties in the processing of figurative language have been linked to the age-related decline of working memory (Kim, Bayles, & Beeson, 2008). More specifically, a study by Qualls and Harris (2003) investigating the cognitive and linguistic factors associated with adults' comprehension of figurative language showed that working memory and reading comprehension played a role in the understanding of the selected figures of speech (including idioms, metaphors and metonyms). Consistently, other studies highlighted the role of working memory in predicting older adults' ability to explain idioms, as well as the link between this cognitive function and proverb comprehension. (Qualls et al., 2001). However, it is important to operate a distinction between different types of figurative language. In fact, some authors suggested that idiom processing might not involve the same amount of working memory effort of metaphor comprehension, since idioms are already stored in our memory and therefore lexicalized. Furthermore, as suggested by previous studies, the working memory load might vary according to the nature of the task used to test figurative language comprehension; in fact, using a verbal explanation vs a forced choice task might determine whether or not age differences will be observed (Gregory & Waggoner, 1996). As for verbal production tasks, it might be the case that the target sentence (which is orally presented and followed by the "What does it mean?" question) is retained in memory until the appropriate answer is formulated and produced. Previous research suggested that older adults are impaired in such tasks, and this difficulty might be due to a reduced working memory capacity (Qualls & Harris, 2003).

Conversely, forced choice tasks might facilitate older participants' performance by reducing the memory load involved in the task; thus, they might represent a more accurate measure of figurative language comprehension abilities in aging (Qualls & Harris, 2003). Furthermore, the role of cognitive and socio-demographic factors in humor comprehension was explored in previous studies, and the main findings showed a relationship with general cognitive skills and education (Daniluk & Borkowska, 2017), working memory and verbal abstract ability (Shammi & Stuss, 2003), inhibition and set-shifting (Uekermann et al., 2006), cognitive flexibility, abstract reasoning and vocabulary (Mak & Carpenter, 2007), as well as ToM skills, especially when reasoning about the mental states of the joke's characters is required (Bischetti, Ceccato, Lecce, Cavallini, & Bambini, 2019). Additional evidence is provided by a recent study showing that affective ToM, measured with the RTME test, is a significant predictor of pragmatic abilities (Bosco et al., 2019). Furthermore, as suggested by Messer (2015), individual differences in language profiles include many aspects, such as socialization, environment, personality, lifestyle and demographic factors, as well as Cognitive Reserve (CR). CR refers to the individual's degree of reinforced neural networks that plays a protective role against cognitive decline or dementia, often in terms of delayed symptom onset (Bialystok, Craik, & Luk, 2012). The CR model posits that cognitive processes are key to explaining the differences between a functionally impaired individual and someone else who is not, despite equal brain changes or pathology. These cognitive processes consist of differences in cognitive efficiency, capacity and flexibility, which are constantly shaped by our experience. CR is usually estimated using variables concerning lifetime exposures and cognitive activity: years of education, number of intellectually stimulating leisure activities, degree of occupational complexity, quality of social interactions, as well as socioeconomic status (Barulli, Rakitin, Lemaire, & Stern, 2013). The role of CR in modulating the cognitive effects of pathology or cognitive decline has been extensively explored. With respect to language, CR has been previously found to be a predictor of verbal comprehension skills, as well as vocabulary size enhancement in healthy elderly (Arbuckle, Maag, Pushkar, & Chaikelson, 1998; Schaie, 1989). To date, less is known about the relationship between pragmatic skills and CR in healthy older adults; evidence of the effect of CR on pragmatic abilities has been provided by Montemurro et al. in patients with Parkinson's disease (PD); more specifically, results revealed that CR is strongly associated with pragmatic skills, especially with comprehension abilities. Thus, the authors suggested that CR might compensate pragmatic difficulties that may arise in PD patients (Montemurro et al., 2018).

4.2.3 Pragmatic abilities and quality of life in aging

As previously stated, pragmatic deficits strongly impact the way people communicate in social contexts and, overall, their quality of life. Changes in the aging body can lead to increasing incidence of injury, illness and cognitive deficits. In this respect, older adults might need to visit health care providers more often, and the importance of the patient-provider relationship has been previously highlighted by the existing literature (Rachel H. Messer, 2015). Rapport building requires both patient and provider to use pragmatic production and comprehension skills. For instance, patients' difficulties with turn-taking might lead to poorer rapport quality, due to the disengagement of the provider after several interruptions. Thus, patient-provider relationship requires a strong social interaction, which relies on pragmatic competence to facilitate a positive health care experience. Additionally, frontal lobe deficits are likely to emerge as we age, leading to significant changes of executive functions and other cognitive domains. Decreased processing speed and inhibitory control, changes of attentional and memory processes as well as difficulties in facial emotion recognition work in conjunction with speech and language processing to achieve effective communication (Rachel H. Messer, 2015).

4.3 Aim of the Research

The present study has three main goals. First, to trace a comprehensive characterization of pragmatic competence in aging, exploring age-related differences in pragmatic skills in three different groups of healthy adults. Second, to explore the relationship between pragmatic competence and other cognitive functions in healthy aging and third, to investigate whether Cognitive Reserve may compensate for pragmatic language difficulties in older adults.

4.4 Methods

4.4.1 Participants

The following three age groups are recruited in the study: i) 15 healthy older adults ranging from 60 to 67 years; ii) 15 healthy older adults ranging from 68 to 75 years; iii) and 15 healthy controls ranging from 20 to 40 years. Exclusion criteria are: 1) the presence of severe cognitive or linguistic deficit; 2) current or past neurological disorders; 3) substance or alcohol use; 4) hearing or vision problems; 5) MMSE < 24. Only participants with sufficient digital skills (e.g., participants with basic computer skills) are included in the sample. All participants are Italian native speakers.

4.4.2 Procedure

All the administered measures require a computer with internet connection, allowing participants to complete each task from their homes. Participants are administered a set of measures in an online format, in the following order: (i) an online survey that collect relevant demographic (age; and education, quantified as number of years of school and university/college courses successfully completed), as well as a self-assessment of their basic digital skills and Cognitive Reserve; (ii) an online survey assessing Theory of Mind; (iii) the APACS test to collect measures for their pragmatic competence; (iv) a battery of selected neuropsychological tests that include a screening battery for cognitive assessment and domain-specific tests. Surveys (i) and (ii) are completed by each participant independently. Tests (iii) and (iv) are administered in fixed order during a Skype session (about 1-hour) with the experimenter.

4.4.3 Measures

Assessment of Pragmatic Abilities and Cognitive Substrates (APACS) (Arcara & Bambini, 2016). This test is administered during the Skype session with the experimenter (see Appendix for details).

Mini Mental State Examination (MMSE) (Ridha & Rossor, 2005). It is a 30-point neuropsychological measure for cognitive impairment. It includes tests for orientation, attention, memory, language and visuo-spatial skills. The final score is corrected for age and education. It is administered during the Skype session with the experimenter.

Digit Span forward and backward (Monaco, Costa, Caltagirone, & Carlesimo, 2013). The final score is then corrected for age and education. These tests are both administered during the Skype session with the experimenter (see Appendix for details).

Stroop task (Stoet, 2010). An online version of the Stroop task is administered using the web-based application Psytoolkit. See Appendix for details.

Corsi task (Stoet, 2010). An online version of the Corsi task is administered using the web-based application Psytoolkit (see Appendix for details).

Cognitive Reserve (Nucci, Mapelli, & Mondini, 2011). It is measured with an online version of the Cognitive Reserve Index questionnaire (CRIq) (Nucci et al., 2012). See Appendix for details.

Digital skills self-assessment. Participants fill a 13-question online survey assessing their basic digital skills.

Faux Pas. 6 stories containing a faux pas and 8 control stories were selected from the Italian version of the Faux pas test (adapted from Stone, Baron-Cohen, & Knight, 1998 by Liverta Sempio, Marchetti, & Lecciso, 2005) and converted to an online questionnaire. This test measures both cognitive and affective ToM.

4.5 Predictions

Consistently with Messer's analysis of pragmatic language changes in aging, we would expect to find a decline of pragmatic skills in older adults, compared to their younger counterpart. This finding would confirm previous research showing significant differences in pragmatic competence in different elderly age groups compared to younger participants (Bosco 2019). Additionally, we would expect to find a relationship between pragmatic skills and other cognitive functions, as well as a predictive role of Cognitive Reserve, in line with previous studies targeting pragmatic language in Parkinson's disease (Montemurro).

5. Phase III: future directions

5.1 Aim of the Research: pragmatic abilities in advanced Parkinson's disease

Advanced stages of PD are characterized by a worsening of motor disabilities, which become more and more invalidating, as well as significant cognitive changes. As a result, pragmatic abilities might undergo a severe impairment as well, but what really happens in advanced stages of PD is yet to be investigated. The aim of this study is to outline a comprehensive characterization of pragmatic disorders in a more advanced stage of PD, with a focus on the impact of these deficits on patients' quality of life.

5.2 Methods

5.2.1 Participants

20 patients with advanced PD (Y&H scores 2.5-3.5) will be recruited at San Martino Hospital (Genoa, Italy), along with a group of 20 matched healthy participants.

5.2.2 Procedure

Participants will be administered a set of measures, in the following order: (i) a survey that collects relevant demographic (age; and education, quantified as number of years of school and university/college courses successfully completed) and clinical information (duration of illness for the PD group, quantified as number of years from onset); (ii) the APACS test (Arcara & Bambini, 2016), to collect measures for their pragmatic competence; (iii) a battery of selected neuropsychological tests that included both screening batteries for cognitive assessment and domain-specific tests. Quality of life will be assessed as well. The tests will be administered in two separate experimental sessions (about 1-hour each), and they will be presented in fixed order to control for fatigue and to reduce cognitive effort across tasks in each session.

5.3 Predictions

With respect to the findings of the first study targeting early PD, it is possible to predict that a more severe and widespread pragmatic impairment will be observed in more advanced stages. Increased motor disabilities and cognitive changes are likely to occur as the disease progresses, and therefore deficits of a wider range of pragmatic domains could emerge. More specifically, we would expect to detect an impairment not only of the Figurative Language 2 task, but also of the Figurative Language 1 task, which did not emerge as compromised in the first study. In other words, we would expect an overall impairment of figurative language comprehension, regardless of the nature of the task. It is also plausible to predict a significant impact of pragmatic impairment on patients' quality of life, possibly due to emerging difficulties in engaging in social relationships and in communicating effectively with others.

5.4 Aim of the Research: metaphor comprehension in Parkinson's disease: the role of inhibitory control

In light of the emerging differences between PD patients and healthy controls in figurative language comprehension and the predictive role of inhibitory control (see study 1 for details), a step forward involves a further exploration of the inhibitory mechanism in metaphor understanding, taking into account the degree of familiarity. Typically, people do not construct the meaning of conventional metaphors, since the sense of the metaphorical expressions is retrieved from the lexicon. Conversely, the comprehension of novel metaphors is more demanding, as more cognitive skills are involved. The main goal of this research is to test the hypothesis that patients with PD are impaired in the comprehension of novel metaphors, compared to high-familiar ones. The second aim is to investigate the role of inhibitory control in metaphor comprehension.

5.5 Methods

5.5.1 Participants

20 patients will be recruited at San Martino Hospital (Genoa, Italy), along with 20 matched healthy controls.

5.5.2 Materials

Participants will complete a metaphor comprehension task. They will be presented with 20 familiar and 20 novel metaphors, for each of which they will be required to provide a verbal explanation. The degree of familiarity of each metaphorical expression will be tested within a preliminary experimental phase. Furthermore, patients' inhibitory control will be assessed with the Stroop task, while cognitive deterioration will be excluded with the administration of the MMSE.

5.6 Predictions

Considering PD patients' difficulties in figurative language comprehension, suggested by the impaired performance in the Figurative Language 2 task in which novel metaphors were presented (see study 1), it is plausible to hypothesize that lower accuracy will be registered for novel vs conventional metaphors in the PD group, as compared to healthy controls. Additionally, we would also expect to observe a predictive role of inhibitory control, which might contribute to the suppression of irrelevant information during a novel metaphor comprehension task.

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Appendix

Neurocognitive measures

Montreal Cognitive Assessment (MoCA)(Nasreddine et al., 2005). Accuracy is collected and a maximal score of 30 can be assigned. The final score is then corrected for age and education (Santangelo et al., 2015).

Parkinson's Disease-Cognitive Rating Scale (PD-CRS). The subcortical score (range 0-104) is obtained by adding the scores of: immediate free-recall verbal memory, sustained attention, working memory, unprompted drawing of a clock, delayed free-recall memory, alternating verbal fluency and action verbal fluency. Second, the cortical score (range 0-30) is obtained by adding the scores of naming and copy drawing of a clock. Third, the PD-CRS Total score (range 0-134) is obtained by adding the subcortical and cortical scores. The three scores are then corrected for age and education.

Digit Span forward. Participants are read a maximum of 9 lists of digits one at a time and asked to repeat these in the same order as the digits were presented to them. The length of the lists gradually increases from three to nine digits. After each list, if participants correctly repeat the set of digits, another list one digit longer is presented; if they fail, a second list of the same length is presented. If subjects succeed the second list, a list one digit longer is presented. If they fail on the second list, the test is ended. The span is established as the length of the longest list correctly recalled. The final score is then corrected for age and education (Monaco et al., 2013).

Digit Span backward. The procedure is the same as for the forward version, except that participants are now asked to repeat the digits sequences in the reverse order and the longest list consists of eight items. The scoring is the same as for the forward version (Monaco et al., 2013).

Corsi Span forward. The experimental apparatus consists of a wooden board with nine cubic blocks. A serial number (from 1 to 9) is located on each block and this is visible only to the examiner. Following a given numerical sequence, the examiner touches sequences of blocks that may range from 3 to 9 blocks. For each sequence, participants are asked to touch the blocks in the same order as the examiner. The first sequence includes 3 blocks. If participants fail, a second sequence of the same length is presented. If they succeed, a sequence one block longer is given. The test ends when participants fail on two consecutive sequences of the same length. The span is computed as the length of the longest sequence correctly reproduced. The final score is then corrected for age and education (Monaco et al., 2013).

Corsi Span backward. The procedure and scoring are the same as for the forward version, except that now participants are asked to reproduce the sequence of blocks in the reverse order and that the longest list includes eight items (Monaco et al., 2013).

Verbal fluency test. The semantic categories were animals, fruits and car brands. The phonemic categories included words beginning with the letters F, P and L. Two scores are obtained, one for semantic fluency and the other for phonemic fluency. In both cases, the score is obtained by counting the number of correct responses (1 score for each correct response) and correcting this for age and education.

Trail Making Test (TMT). It is made up of two parts, A and B. In Part A, participants are required to connect 25 numbered circles with direct line in ascending order (i.e., 1-2-3-4…); in Part B, participants are asked to connect numbered and lettered circles in alternated numerical and alphabetical order (i.e., 1-A-2-B-3-C…). A composite score is obtained by subtracting the time for A to the time for B (i.e., B-A). The final score is then corrected for age and education (Siciliano et al., 2019).

Stroop test (short version). Participants are required to read aloud three lists of items as fast as possible. In the first two lists, participants are asked to read respectively a set of words for colors that are printed in black ink (List I) and to name the color of a set of circles (List II). In the third list, color-words are printed in an inconsistent color ink (e.g., the word "blue" is printed in red ink) and participants are required to name the color of the ink, while inhibiting reading the word. For each of the 3 tasks, time of completion and accuracy are collected. Both a time interference effect (based on execution time) and an error interference effect (based on number of errors) are computed. The final scores are then corrected for age and education (see Caffarra, Vezzadini, Dieci, Zonato, & Venneri, 2002).

"Valutazione delle capacità di costruzione dello scheletro" (Semantic Memory 1 task) and *"Denominazione visiva"* (Semantic Memory 2 task). In the first task, participants are presented with a set of animals and asked to say if the animals are bigger or smaller than a goat. Twenty questions are presented; answers are coded as 1 or 0, respectively for correct and incorrect responses. Afterwards, participants are presented with 20 objects and asked to say if each of these is higher or wider (e.g., 'is a wardrobe higher or wider?'). Correct answers are coded as 1, incorrect answers are coded as 0. The final score is obtained by counting the correct answers, for a maximal score of 40. In the second task, participants are presented with 64 pictures and asked to mention the name of every object in the pictures. If they successfully name the object, a score of 1 is assigned; otherwise, a score of 0 is assigned. The final score is obtained by counting the correct answers, for a maximal score of 64.

Emotion Attribution Test (EAT). Participants are presented with 35 short stories and are asked to identify the characters' emotions. A score of 1 is assigned for each emotion correctly identified. The maximum score is 35.

Advanced ToM Task. Participants are presented with 13 short stories and are asked to explain why the main character acted in a given manner. A score of 1 is assigned for each correct response. The maximum score is 13.

Reading the Mind in the Eyes test (RMEt). Participants are presented with 36 gray-scale photos of people faces that show only the area around the eyes. For each photo, participants are asked to choose the word (out of 4) that best describes the person's mental state. The final score is obtained by counting the correct answers (0-36).

Beck Depression Inventory II (BDI-II). Participants are asked to rate the severity of each item/symptom in the last two weeks from the day of the test on a 4-point Likert scale that ranges from 0 to 3. The total score ranges from 0 to 63, with higher scores indicating more severe depressive status.

Online Stroop task (https://www.psytoolkit.org/experimentlibrary/experiment_stroop.html). The task consists of a training session and three experimental sessions. Participants are provided with both oral and written instructions at the beginning of each session. Three color names and three colored circles were selected as stimuli (color name "giallo", yellow circle, color name "verde", green circle, color name "blu" and blue circle). During the training session, participants are presented with color names written in white ink and with the selected colored circles, which are displayed in random order. Each stimulus appears on a black screen, with a maximum time limit of 2000 ms. Participants are instructed to press a button on the keyboard that corresponds to the color name or to the color of the circle as fast as possible (e.g., they have to press the "g" key if the word "giallo" or the yellow circle appears). The training session consists of 18 stimuli. In the first experimental session (first congruence condition), 30 color words written in white ink appear one at a time on a black screen. Participants are required to press a button on the keyboard that corresponds to the color name as fast as possible (e.g., they have to press "v" if the word "verde" appears). In the second experimental session (second congruence condition), 30 colored circles appear one at a time on a black screen. Participants are required to press a button on the keyboard that corresponds to the color of the circle as fast as possible (e.g., they press "b" if the blue circle appears). The third experimental session (incongruence condition) consists of 30 colored words written in an inconsistent color ink (e.g., the word "giallo" is displayed in blue ink), and participants are asked to press the button on the keyboard that corresponds to the color of the ink (they press "b" since the word is displayed in blue ink). Late responses (later than 2000 ms) in the experimental sessions are counted as an error. An output table reports both reaction time and accuracy values for each stimulus of the three sessions. Participants complete this test with their own computer during the Skype session under the supervision of the experimenter.

Online Corsi task (Psytoolkit). Nine irregularly arranged blue cubes are displayed on the screen. A certain number of cubes changes its color and temporary becomes yellow in a specific order; after this color transition (700 ms), it goes back to blue. This fast color change is equal to the examiner touch in the classical version of the Corsi task: it indicates which of the presented cubes need to be memorized. Participants are then asked to select the cubes that temporally changed color in the reverse order using their mouse. The length of the sequence increases the more correct sequences participants complete. A training session with length ranging from 2 to 3 blocks is provided at the beginning of the task. The first sequence requires participants to memorize two cubes in the reverse order. If they fail, a second sequence of the same length is presented. If they succeed, a sequence one block longer is displayed. The test ends when participants fail on two consecutive sequences of the same length. The span is computed as the length of the longest sequence correctly reproduced. The final score is then corrected for age and education. Participants complete this test with their own computer during the Skype session under the supervision of the experimenter.

Cognitive Reserve Index. The original CRIq, which consists in a semi-structured interview, was adapted to an online questionnaire format. Written instructions are presented at the beginning of the online questionnaire, which requires about 10 minutes to be filled and includes twenty questions grouped into three sections: Education (CRI-Education), Working activities (CRI-WorkingActivity), and Leisure time activities (CRI-LeisureTime). CRI-Education is made up of years of formal education and any additional training courses lasted at least 6 months. CRI-WorkingActivity refers to the cognitive load and personal responsibility of an occupation, combined with the number of years for which the occupation has been carried out for a minimum of 5 years. Finally, CRI-LeisureTime measures the frequency and the amount of intellectual, social, and physical activities (e.g., reading newspapers or books, playing music, participation in charitable activities, traveling, doing sports, etc.) carried out for a minimum of 5 years. The questionnaire also includes additional items about life-long experiences that require a certain cognitive load (e.g., years of bank account management). The CRI Total score is an estimation of Cognitive Reserve. It is the average of the three subscores standardized and transposed to a scale with a mean of 100 and a standard deviation of 15 (see Nucci et al., 2012 for details). The CRI Total score can be classified into five ordered levels: Low (less than 70), Medium–low (70–84), Medium (85–114), Medium–high (115–130) and High (more than 130).

Digital skills self assessment. Participants are asked whether they own a computer, a tablet and a smartphone, how often each of these tools is used and what they usually do with them (browsing the internet, sending e-mails, writing documents, video-calling, etc.). Participants are then asked to rate their degree of autonomy in using digital tools (e.g., the ability to distinguish between different electronic devices and their functions, the ability to use a mouse, touchpad, touchscreen and the keyboard, the ability to identify the menu, to localize and save files, as well as the ability to fill documents and surveys).

Faux Pas. Participants read a series of 6 short stories containing a faux pas, as well as 8 control stories that do not contain a faux pas. Faux pas stories and control stories are presented in mixed order. Participants have no time limit and they are allowed to read the stories as many times as necessary in order to fully understand them.
Each story is followed by a series of questions: (1) detection questions (*Did someone say something they shouldn't have said*?), (2) person identification question (*Who said something they shouldn't have said*?), (3-4) faux pas questions (*Why shouldn't they have said what they said?*; *Why do you think they said what they said?*), (5) false belief question (*Did Antonio know that Maria and Giulia did not know each other*?), (6) affective question (*How do you think Giulia felt*?), and (7-8) control questions (*Where was Giulia in the story?*; *Did Giulia and Maria know each other?*). The cognitive ToM component was assessed via the false belief question (question 5), which tested whether participants understood the false beliefs of who committed the faux pas. The affective ToM component was assessed via the affective question (question 6), which tested the emphatic understanding of how the person in the story would feel. Questions 2–6 were asked only if participants detected the faux pas, that is, answered Yes to the first question. If he or she said No, they were presented with the control questions (7-8). One point was given for each correct answer, so that scores for each question/component of the faux pas stories ranged from 0 to 7.

The control stories were in the same format as the faux pas stories, but had a different scoring system. Two points were given for the first question; zero points for a wrong response.