**Cognitive abilities and theory of mind in explaining communicative-pragmatic disorders in patients with schizophrenia**

# Cognitive abilities and theory of mind in explaining communicative-pragmatic disorders in patients with schizophrenia

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Abstract

Patients with schizophrenia usually show an impairment in their communicative-pragmatic performance; they also have difficulties in cognitive functioning and Theory of Mind (ToM). In the literature it has been proposed that ToM and cognitive functioning deficits have a role in explaining the communicative-pragmatic difficulties of patients with schizophrenia. However, the exact interplay of these functions is still not completely clear.

The present research investigates the relationship between communicative-pragmatic, ToM and cognitive functionning mpairments (i.e. general intelligence, selective attention, speed processing and EF -working memory, inhibition and flexibility-) in a sample of 26 individuals with schizophrenia. The linguistic and extralinguistic scales of the Assessment Battery of Communication (ABaCo), and a series of ToM and cognitive tasks were administered to patients and healthy controls. The results showed that individuals with schizophrenia performed less well than controls in all the tasks investigated. However, only ToM, and not cognitive functions, seems to be a predictive variable of patients' performance.

Keywords: Pragmatics, communication disorders, exective functioning, theory of mind, mindreading, schizophrenia

## 1. Introduction

A well-established notion in the literature is that patients with schizophrenia often show pervasive difficulties in the communicative-pragmatic domain (Cummings, 2017, Bambini et al., 2016; Colle et al., 2013, Langdon et al., 2002). Pragmatics refers to the communicative use of language (Levinson, 1983) and other expressive means such as non-verbal/extralinguistic modalities, for example gestures, in a certain context (Bara, 2010). Several studies have shown that communicative difficulties may persist even when patients' syntactic and semantic abilities are intact (Andreasen et al., 1985; Frith and Allen, 1988; Moro et al., 2015).

The difficulties shown by individuals with schizophrenia encompass various aspects of communicative competence. Bazin et al. (2005) assessed patients' ability to manage a conversation on everyday topics using the Schizophrenia Communication Disorder Scale, a structured interview consisting of items relating to the patient's difficulties to integrate contextual information and to attribute intention to partners. The results showed that individuals with schizophrenia performed worse when compared with people affected by mania or depression. Furthermore, Linscott et al. (2005), using the Profile of Functional Impairment in Communication (Linscott et al., 1996), pointed out that patients had a higher index of pragmatic impairment compared with healthy controls. Marini et al. (2008) found patients with schizophrenia to be impaired in managing narrative aspects of communication. More recently, Bambini et al. (2016) provided a comprehensive description of pragmatic ability in individuals with schizophrenia using the Assessment of Pragmatic Abilities and Cognitive Substrates test (APACS, Arcara & Bambini, 2016), The authors confirmed the high frequency of pragmatic impairment in schizophrenia, and they also found an association between pragmatic impairment and a reduction of quality of life of these patients. Several studies have also reported that individuals with schizophrenia performed worse than controls in the comprehension of non-literal and figurative language, such as indirect speech acts (Corcoran et al., 1995; Corcoran, 2003), proverbs (Haas et al., 2014;), irony (Langdon

et al., 2002; Gavilán and García-Albea, 2011), metaphors and idioms (Tavano et al., 2008; Schettino et al., 2010; Pesciarelli et al., 2014). Moreover, patients may have difficulties managing deceitful communicative acts (Frith & Corcoran, 1996), violation of Grice's maxims (Tényi et al., 2002; Mazza et al., 2008) and in the recognition and recovery of communicative failures (Bosco et al., 2012a).

Not only linguistic but also non-verbal/extralinguistic difficulties, such as facial expression recognition, are an integral part of schizophrenic pathology (Stein, 1993; Stassen, 1991; Stassen et al., 1995; for a review, see Edwards et al., 2002). Del-Monte et al. (2013) investigated non-verbal expressive behavior in schizophrenia, examining the production of gestures, i.e., smiles, spontaneous hand gestures, speech flow and facial expressions, during a structured interview. The authors found that individuals with schizophrenia, compared with patients with phobia and healthy controls, used fewer spontaneous gestures, i.e., hand movements and smiles, which is associated with poor social functioning, Kupper et al. (2010), analyzing videotaped role-play scenes, also observed a significant reduction in the use of head and body movements among patients with schizophrenia.

Testing both the linguistic and non-verbal/extralinguistic aspects of conversation, Meilijson et al. (2004) pointed out that patients with schizophrenia exhibited inappropriate communicative abilities compared with participants with mixed anxiety-depression disorder and participants with hemispheric brain damage. Furthermore, Colle et al. (2013), using the assessment Battery for Communication (Angeleri et al., 2012), analyzed both linguistic and extralinguistic means of expression and investigated patients' ability to comprehend and produce different sorts of pragmatic phenomena, such as direct and indirect communicative acts, deceit and irony. The results showed that participants with schizophrenia performed significantly worse when compared with normative data for healthy controls on the ABaCo (Angeleri et al., 2012) on all the evaluation scales (linguistic, extralinguistic, paralinguistic, contextual and conversational) in both comprehension and production tasks.

Furthermore, as we will see in more detail in the following section, in recent years (Mossaheb et al., 2014; Pesciarelli wet al., 2013; Gavilàn & Garcia-Albea, 2011; Champagne-Lavau & Stip, 2010;) there has been growing interest in determining whether the communicative-pragmatic difficulties of individuals with schizophrenia are due to an underlying deficit in other cognitive components, such as general intelligence, selective attention, speed processing and executive functions, i.e. a set of cognitive control mechanisms that allow to execute and regulate goal directed behaviour and problem solving (Miyake et al., 2000; Miller & Cohen, 2001), or to a deficit in theory of mind, i.e., the ability to attribute mental states to oneself and to other people, in order to predict one's own and others' behaviour (Premack & Woodruff, 1978 ).

The aim of this paper is to investigate whether deficits cognitive abilities and ToM might contribute to explaining the linguistic and extralinguistic communicative-pragmatic difficulties of patients with schizophrenia.

### 1.1 Cognitive deficits in schizophrenia

Frith (1992) was the first author to suggest that patients with schizophrenia suffer from a ToM deficit. Over the last decades, several studies have confirmed Frith's hypothesis (Corcoran et al., 1995; Frith & Corcoran, 1996; Corcoran et al., 1997; Mazza et al., 2001; Sarfati & Hardy-Baylé, 1999; Brune, 2005; Bosco et al., 2009; for a review see Harrington et al., 2005; Green et al., 2015). More specifically, according to Frith's proposal, the communicative-pragmatic difficulties shown by patients with schizophrenia are due to a primary ToM deficit. An intact and fully developed ToM (Bosco et al. 2014; Brizio et al. 2015) is necessary to manage communicative interaction (Tirassa, Bosco & Colle 2006). Many subsequent studies have reported the co-occurrence of ToM deficits and pragmatic impairments in a variety of tasks (for a recent review see Key-DeLyria and Altman, 2016), such as the comprehension of non-literal and figurative forms of language as indirect requests and hints, metaphors, proverbs and irony (Corcoran et al., 1995; Langdon et al.,

2002; Brune & Bodestein, 2005; Mo et al., 2008; Champagne-Lavau & Stip., 2010; Gavilàn & Garcia-Albea, 2011), recognition of the violation of Gricean maxims and social norms of communication (Corcoran & Frith, 1996; Mazza et al., 2008), incorrect use of cohesive devices and referential markers during conversation (Abu-Akel & Bailey 2000; Champagne-Lavau et al., 2009), and recognition and recovery of communicative failure (Bosco et al., 2012a).

The above-mentioned studies appear to provide convincing evidence that ToM impairments contribute to explain the differences in pragmatic performance between patients with schizophrenia and healthy controls. However, some authors (Thoma & Daum, 2006; Thoma et al., 2009; Sponheim et al., 2003; Mossaheb et al., 2014) have proposed that ToM deficits in individuals with schizophrenia could be more properly referred to a deficit in another cognitive component, i.e., executive functioning (EF). EF refers to a set of complex abilities generally associated with the activity of the frontal brain areas (Eisenber & Berman, 2010) that allow people to perform goal-directed behaviour in a flexible and effective way by planning actions and decisions in a sequential and hierarchical order, monitoring and correcting performance during task execution, maintaining a goal over time, and adapting it to the specific request set by the surrounding context (Miyake et al. 2000).

Several studies in the literature have pointed out that patients with schizophrenia have difficulties in solving cognitive and EF tasks (Weickert et al. 2000; see also Reichenberg and Harvey 2007), as well as in general intelligence (Linscot, 2005). Since communicative-pragmatic competence requires the complex interplay of different cognitive abilities, such as general intelligence, EF and ToM, difficulties in cognitive functioning, shown by patients with schizophrenia could negatively influence their communicative-pragmatic performance. The study of the cognitive underpinnings of pragmatic disorders in schizophrenia has principally focused on the comprehension of figurative forms of language such as metaphors and proverbs. Sponheim et al. (2003) evaluated proverb comprehension in patients with schizophrenia, investigating the contribution of EF, i.e. planning, set-shifting and WM. Proverb interpretations were rated as literal,

concrete, abstract or bizarre-idiosyncratic and the results showed that only a poor concrete interpretation was related to EF. In line with this study, Thoma et al. (2009) found that patients with schizophrenia obtained lower scores in proverb comprehension tasks when compared with healthy controls and patients with alcohol dependence. The results showed that among the EF skills (WM, divided attention, set-shifting and inhibitory control) only divided attention correlated with patients' poor proverb recognition. Recently Mossaheb et al. (2014) assessed patients' ability to comprehend both conventional and non-conventional (novel) metaphors and their performance on the following cognitive and EF skills: verbal vocabulary, speed processing, verbal and non-verbal intelligence, inhibition and cognitive flexibility. The results showed that the patients were impaired in all the tasks examined, and that this impairment was related to executive dysfunction; however, only cognitive flexibility predicted patients' performance in the recognition of conventional metaphors, while vocabulary predicted performance in terms of novel metaphor comprehension.

Of the studies in the literature that have tried to explain pragmatic impairment, few have considered ToM and EF concurrently. One example is the work by Brune & Bodestein (2005), which analyzed the role of ToM and EF, in terms of cognitive flexibility and planning ability, in proverb comprehension. The authors observed an association between the comprehension of proverbs and each of the other EF and ToM skills analyzed. They also conducted a regression analysis, from which ToM emerged as the best predictor of pragmatic competence, accounting for a notable proportion of the variance, whereas the only important contribution of EF was cognitive flexibility, which was associated with a significant, albeit limited part of the variance. Mazza et al. (2008) looked for evidence of an association between ToM deficits and pragmatic impairments and schizophrenia, and their independence from EF. The authors administered a pragmatic task in which patients were required to listen to short conversations and then choose the most relevant answers to the questions that were asked, for example: "What did you have for lunch? a) Some food * b) Pizza". ToM was also investigated via a false belief task, and EF (planning and cognitive flexibility). Patients performed worse than the controls in both the ToM and pragmatic tasks, and

these differences remained after controlling for the role of EF. Moreover, the authors found a correlation between ToM and the pragmatic tasks. Lastly, again in patients with schizophrenia, Champagne-Lavau and Stip (2010) investigated the role of ToM and EF (shifting, inhibitory control and cognitive flexibility) in the comprehension of pragmatic meaning (indirect requests, idiomatic metaphors and non-idiomatic metaphors). They observed an association between pragmatic comprehension and cognitive flexibility and shifting, though no correlation with inhibitory control. The differences between the scores of patients and controls in pragmatic tasks were still evident even after controlling for the role of EF. Such differences were still observed after controlling for the role of ToM, but only for non-idiomatic metaphor comprehension and not for the other pragmatics tasks (indirect requests and idiomatic metaphors). The authors pointed out that ToM abilities are only required in the comprehension of idiomatic metaphors, whereas different cognitive processes are used to comprehend non-idiomatic metaphors (see also Giora, 2002; Bosco, Vallana & Bucciarelli; 2009a, 2012a and see Bosco for other forms of non literal expressions as irony. The results of this study, similarly to those of Brune and Bodenstein (2005), suggest that metaphor comprehension may be related to ToM processes beyond the contribution of EF.

Considered as a whole, the studies discussed above are not sufficient to establish the exact role played by ToM in explaining a patient's performance in a specific pragmatic task when compared with others, and suggest that this can vary greatly according to the pragmatic phenomenon investigated. Furthermore, despite their valuable contribution, in our opinion one limit of these studies is that they only focused on the linguistic means of expression (e.g. Bazin et al., 2005; Tan, et al.,, 2014) overlooking other expressive modalities such as non-verbal/extralinguistic means, and mainly concentrated on certain aspects of figurative language, namely metaphors and proverbs. No previous studies have evaluated, in the same group of patients, the relationship between cognitive abilities, i.e., EF and ToM, and pragmatic competence expressed using linguistic and extralinguistic modalities.

**The present study**

The aim of the present study was to investigate the role that ToM and cognitive functioning have in determining communicative-pragmatic difficulties in patients with schizophrenia. In line with the study by Colle et al. (2013) we hypothesized that communicative-pragmatic performance of patients with schizophrenia would be worse than that of healthy controls in both comprehension and production tasks on the linguistic and extralinguistic scales of the Assessment Battery for Communication (ABaCo,; Angeleri et al. 2012). We also expected individuals with schizophrenia to perform worse than controls in the cognitive and theory of mind tasks administered: general intelligence, selective attention, speed processing, EF (cognitive flexibility, inhibition and working memory) and ToM. However, we also wanted to test the association between pragmatic impairment and cognitive functions, and theory of mind impairments. Lastly, we expected to establish (through a hierarchical regression analysis) the role of such cognitive functions, and ToM, in explaining patients' pragmatic difficulties, considering comprehension and production and linguistic and non-verbal/extralinguistic ability as separate aspects.

## 2. Method

### 2.1 Participants

Twenty-six individuals with schizophrenia (21 males, 5 females) were recruited from the outpatient clinic of the Department of Mental Health of the district of Ceva and Mondovi and of the district of Turin. All patients met the DSM-IV criteria for diagnosis of schizophrenia. (American Psychiatric Association, 1994). Individuals with schizophrenia were chronically ill and clinically stable (no hospitalization in the last 6 months and no changes in the antipsychotic therapy in the last 3 months). Patients had to meet the following inclusion criteria: 1) Italian native speakers 2) achieve a cut-off score in the following neuropsychological tests to exclude the presence of severe cognitive

or linguistic deficits: Mini Mental State Examination (MMSE; Folstein et al., gh, 1975, cut-off: 24/30), Token test (De Renzi & Vignolo, 1962**;** cut-off: 5/6); denomination scale of the Aachener Aphasie test (AAT, Huber et al., 1983, cut-off: no deficit) 3) provide their informed consent. Patients' symptomatology was examined by administering the Positive and Negative Syndrome Scale (PANNS; Kay et al.,, 1987).

A group of 26 healthy controls, matched with patients for sex (21 males, 5 females), age ($t = .57$, $p = .95$) and education ($t = .45$, $p = .65$), took part in the study.

Exclusion criteria for both groups were: 1) evidence of current or past neurological disorder (e.g., epilepsy) 2) substance or alcohol use disorder 3) anamnesis of major neurological or neuropsychological disease 4) hearing or vision problems 5) history of head injury. Demographic and clinical measures of patients and controls are displayed in Table 1.

-Table 1 about here -

**2.2 Materials**

**Communicative-Pragmatic assessment**

To evaluate communicative-pragmatic performance we used the Linguistic and Extralinguistic Scales of the Assessment Battery for Communication (ABaCo, Angeleri. et al., 2012; Bosco et al., 2017a). The linguistic and extralinguistic scales assess the ability to comprehend and produce different communicative acts, i.e., sincere communicative acts (direct and indirect), deceit and irony, expressed through the use of language on the Linguistic scale or through non-

verbal modalities (e.g., extralinguistic features such as gestures or facial expressions) on the Extralinguistic scale. Each scale comprises a comprehension and production subscale, that assesses these abilities in each communication modality, i.e. linguistic and extralinguistic. Each scale comprises a series of tasks that require participants to understand or produce a communicative act in response to a prompt by the examiner, or to a video-recorded scene in which two actors play out a communicative exchange. The utterances produced by the actors in each scene contained a controlled number of words (7 ± 2), in order to maintain a constant memory and attention requirement. By using these scales, the ABaCo Battery provides a global index of communicative-pragmatic performance. More details on the organization of the Assessment Battery for Communication and its scoring procedures are provided in Parola et al., (2016), Angeleri et al., (2016), Sacco et al., (2008), Bosco et al., (2013).

**2.3 Cognitive assessment**

In order to determine how the patients' cognitive performance could influence their pragmatic abilities, in line with previous studies (e.g., Honan et al., 2015; Bosco et al. 2017) the participants were evaluated with a series of cognitive tasks. **,** First, in order to rule out their possible role in determine patients' performance we assessed a set of background cognitive functions that we considered necessary to solve any tasks: i.e., general intelligence, by using Raven's Coloured Progressive Matrices (RCPM, Raven, 1956), speed processing by administering the Trail Making test (Part A, Reitan, 1958) and selective attention, by administering the Attentive Matrices (Spinnler & Tognoni, 1987). In order to investigate EF we evaluated: Working memory by administering the Disyllabic Word Repetition test and Corsi's Block-Tapping test (Spinnler & Tognoni, 1987, Inhibitory control by using the Modified Card Sorting test (Nelson, 1976) and Cognitive flexibility, by using the Trail Making Test Part B – Part A (Reitan, 1958). Finally, Theory of Mind was assessed by administering the Sally & Ann task (Wimmer & Perner, 1983), the Smarties task (Perner et al., 1989) and a selection of Strange Stories tasks (Happé, 1994).

**2.4 Data analysis**

In order to examine the differences between patients' and healthy controls' pragmatic performance, we submitted the scores obtained on the ABaCo to a 2x2x2 repeated measures analysis of variance (ANOVA) with Scale (two levels: linguistic and extralinguistic) and Task (two levels: production vs. comprehension) as the within-subjects factor, and Group (two levels: patients vs. controls) as the between-subjects factor.

To compare the cognitive performance of patients and controls, we carried out a series of independent-samples *t*-tests for each of the cognitive tasks examined, i.e., general intelligence, selective attention, speed processing, working memory, inhibitory control, cognitive flexibility and Theory of Mind.

To investigate the relationship between pragmatic performance and clinical measures, we used Pearson's correlation coefficient. We calculated Pearson's correlation coefficient between scores on the ABaCo and duration of illness, PANNS total, total positive and total negative symptoms scores.

To verify whether there was a strong relationship between pragmatic impairment and cognitive and theory of mind deficits in the patients' group, we analyzed contingency tables using Fisher's exact test. We defined the presence of a pragmatic deficit when a patient's score on at least two of the subscales of the ABaCo was below the $10^{th}$ percentile of the corresponding demographic group's normative data (see Angeleri et al., 2012). We defined the presence of cognitive deficits when a patient obtained an equivalent score $\leq 1$ in at least two cognitive tests, i.e. general intelligence, selective attention, speed processing and executive functions tests. Finally, we defined the presence of a theory of mind deficit when a patient obtained an overall score in the theory of mind tasks that was two SDs below the mean of the control group.

Lastly, to better analyze the influence of cognitive and theory of mind tasks on pragmatic performance in individuals with schizophrenia, we performed a hierarchical regression analysis. We

included relevant predictors in the model in three consecutive stages, on the basis of their increasing importance in determining pragmatic performance. In particular, in the first step we entered the cognitive background factors (general intelligence, selective attention, speed processing), that we considered necessary to solve any tasks and demographic characteristics (age and years of education). In the second step we entered executive functions (working memory, cognitive flexibility and inhibitory control) as predictors. In the third and final step we entered theory of mind.

Executive functions (EF) were entered in the second step because they can be considered a set of top-down mental processes necessary to control and regulate goal-directed behavior (Diamond, 2013; Miyake et al., 2000); Thus, we want to evaluate the influence of EF on pragmatic performance after controlling for more cognitive-background functions (selective attention, general intelligence and speed processing) and demographic characteristics in the first step of the model. Theory of mind was entered in the final step, after including the executive functions, since some authors have theoretically sustained (Bloom and German, 2000) and empirically verified (Pickup, 2008; McDonald et al., 2014; Honan et al., 2015) the influence of executive functions on solving theory of mind tasks. The analysis was conducted separately for each of the four subscales of the ABaCo (linguistic comprehension, linguistic production, extralinguistic comprehension, extralinguistic production). We checked for collinearity between predictors.

## 3. Results

### 3.1 Pragmatic performance

Descriptive statistics of participants' performance on the four subscales of the ABaCo are summarized in Table 2. The comparison of patients' scores on the ABaCo with normative data for the corresponding demographic group revealed that 92% of patients scored below the $10^{th}$ percentile on at least one of the ABaCo subscales, while 77% of patients scored below the $10^{th}$ percentile in at least two of the ABaCo subscales.

The ANOVA revealed a main effect of Group ($F_{(1,50)} = 51.41$; $p < .001$; $\eta^2_p = .51$), indicating that patients performed significantly worse than healthy controls on the ABaCo, and a main effect of Scale ($F_{(1,50)} = 26.69$; $p < .001$; $\eta^2_p = .35$), indicating better performance on the linguistic scale than on the extralinguistic scale of the ABaCo. The effect of Task was not significant ($F_{(1,50)} = .01$; $p = .92$; $\eta^2_p = .00$), indicating that no differences were found in comprehension vs. production tasks. No interaction effect was significant.

-Table 2 about here -

**3.2 Cognitive performance**

Table 3 summarizes the participants' scores in each cognitive task administered.

The results showed that patients achieved significantly lower scores than controls in all the cognitive tasks examined ($3.35 < t < 6.75$; $.0001 < p < .047$), with the sole exception of the Smarties task ($t = 1.81$, $p = .077$).

-Table 3 about here -

**3.3 Relations between pragmatic performance and clinical measures**

No significant correlation between communicative performance in the ABaCo and the clinical measures – duration of illness, PANSS total, positive and negative scale - was observed ($008 < r < .320$; $.147 < p < .972$).

**3.4 Explanatory role of cognitive functions and theory of mind.**

The contingency table of pragmatic and cognitive deficits of individuals with schizophrenia is reported in Table 4. Fisher's exact test was not significant (p = .60) indicating that there was no stable significant relationship between cognitive deficits, i.e. executive functions and ToM deficits, and pragmatic performance. In particular, 15.4% of patients who exhibited pragmatic deficits did not show cognitive impairments, while only 7.7% of patients who exhibited cognitive deficits showed no pragmatic impairment.

The contingency table of pragmatic and theory of mind deficits of individuals with schizophrenia is reported in Table 5. Fisher's exact test was not significant (p = .20) indicating that there was not a stable significant relationship between theory of mind deficits and pragmatic impairment. In detail, 38.4 % of patients who showed pragmatic impairment did not exhibited theory of mind deficits, while only 3.8% of patients who showed theory of mind deficits showed no pragmatic impairment

-Table 4 about here –

-Table 5 about here -

To explore the relationship between cognitive functions and theory of mind on pragmatic performance in more detail, we performed a Hierarchical regression analysis on a sample of patients with schizophrenia. The analysis revealed a significant influence of cognitive factors and theory of mind on pragmatic performance. In detail, the insertion of cognitive background factors (general intelligence, speed processing and selective attention) and demographic characteristics (age and education) in the first step of the model did not contribute to significantly increase the quota of explained variance. The insertion of executive functions in the second step did not significantly increase the fit of the model. However, by entering theory of mind in the third and last step of the model, significant changes in $R^2$ were observed on the linguistic comprehension subscale ($F_{(1,15)}$ =

6.96; $p = .019$; $\eta^2_p = .35$), explaining an additional 21% of variance in pragmatic scores, and on the linguistic production subscale, ($F_{(1,15)} = 16.77$; $p = .001$; $\eta^2_p = .46$), explaining an incremental 45% of variance.

-Table 6 about here -

## 4. Discussion

The main interest of this study was to shed further light on the interplay between deficit of cognitive functions and theory of mind, and pragmatic impairment in schizophrenia, that is still under debate (see Martin & MCDonald, 2003; Cummings, 2017). Few studies examined in schizophrenia the relationship between all these cognitive functions altogether, and result are mixed (Brune & Bodestein, 2005; Mazza et al., 2008; Champagne-Lavau & Stip, 2010). In addition, to our knowledge only one study examined the relationship between the ability to communicate using both linguistic and extralinguistic, i.e. non verbal, modalities, and theory of mind (Lavelle et al., 2012).

The results indicated that individuals with schizophrenia exhibited severe pragmatic impairment, performing worse than controls on both the linguistic and extralinguistic scales of the ABaCo. The impairment was not limited to the comprehension tasks of the ABaCo, but it also extended to production tasks, confirming the severity of the impairment as documented by the large effect size. The comparisons of patients' scores with normative data for the battery (Angeleri et al., 2012) confirmed the high incidence of pragmatic disorders in this population, with 92% of patients scoring below the 10$^{th}$ percentile on at least one of the ABaCo subscales, and 77% of patients scoring below the 10$^{th}$ percentile on at least two of the ABaCo subscales. This result is in line with previous studies (Bambini et al., 2016; Colle et al., 2013; Marini et al. 2008; Bazin et al., 2005; Linscott et al., 2005; Frith et al., 1995) that have widely documented pragmatic impairment in

schizophrenia. Interestingly, the results confirm that pragmatic impairment also affects the extralinguistic/non-verbal modality, which has received less attention than the verbal one in the past. The ability of patients to effectively comprehend and produce non-verbal signals, i.e. gestures and facial expressions, is impaired to the same extent as the ability to communicate through language (Lavelle et al., 2012; Dal Monte et al., 2013; Colle et al., 2013). As suggested by some studies, non-verbal expressivity is crucial to allow patients to interact successfully, and thus extralinguistic deficits can seriously contribute to the difficulties shown by these patients in managing conversation, and to the reduction of quality of life and poor social functioning (Mittal et al., 2011; Del-Monte et al., 2013).

First, we examined the pattern of co-occurrence of pragmatic and cognitive, and theory of mind deficits, and the results showed that there is no stable relationship between cognitive and theory of mind deficits and pragmatic impairment. For what concerns cognitive deficits, although 60% of patients reported both cognitive deficits and pragmatic impairment, 14% of those who showed pragmatic impairment did not show any cognitive deficits. Considering theory of mind deficits, while 38.4% of patients reported both theory of mind and pragmatic deficits, 38.4 % reported pragmatic impairment not showing any theory of mind deficits. This result suggests that pragmatic impairment cannot simply be reduced to cognitive or theory of mind deficits, and points instead to a specificity of these disorders in line with the results reported by Bambini et al., (2016) in patients with schizophrenia.

To further explore the relationship between cognitive functions and pragmatic ability, we used a hierarchical regression model to examine the influence that cognitive background factors (general intelligence, speed processing and selective attention) executive functions (cognitive flexibility, inhibition and working memory) and theory of mind, can exert in determining pragmatic performance on the linguistic and extralinguistic scales of the ABaCo. We found that the inclusion of general cognitive abilities and executive functions in the model did not provide a significant increase in the explained variance of patients' pragmatic performance. Differently, the inclusion of

theory of mind was found to be significant, helping to explain an incremental quota of variance on the linguistic comprehension and linguistic production subscales of the ABaCo.

First of all, such results suggest that, in our sample, pragmatic impairment was not due to a generalized decline in cognitive functions or general intelligence. At the group level, patients showed severe deficits in cognitive background factors, i.e. general intelligence, speed processing and selective attention, but these deficits did not help to explain their pragmatic performance on any of the four subscales of the ABaCo. Although some authors have suggested and found that a general cognitive impairment could be responsible for communicative deficits in schizophrenia (Linscot, 2005; Varga et al., 2014; Merril et al., 2017), other studies have not found any relationship between solving pragmatic tasks and general cognitive impairment measured through IQ (Brüne and Bodenstein, 2005; Mo et al., 2008; Thoma et al., 2009; Gavilan & Garcia-Albea, 2011). Even the inclusion of executive functions in the model did not contribute to increase the quota of explained variance on any of the ABaCo subscales. Some studies have found a correlation between communicative deficits and executive functions in schizophrenia (Sponheim et al., 2003; Mossaheb et al., 2014; Pasciarelli et al., 2014), however these studies focused on the comprehension of metaphorical and idiomatic expressions. Moreover, several studies have found that the difference between pragmatic performance of patients and controls still persists after controlling for executive functions (Brune & Bodenstein, 2005; Mazza et al., 2008; Champagne-Lavau & Stip, 2010.). In line with these studies, our data suggest that executive dysfunction is not the key factor in explaining pragmatic disorders in schizophrenia. The most interesting finding of this study is the role of theory of mind in explaining patients' pragmatic performance, on both the linguistic comprehension and linguistic production subscales of the ABaCo. This datum is in line with a previous study that observed a relationship between the ability to infer other people's mental states and pragmatic ability (Champagne-Lavau & Stip, 2010; Mazza et al., 2008; Abu-Akel & Baileys, 2000; Corcoran et al., 1996). In line with the original proposal by Frith (1992), the ability to correctly infer other people's mental states seems to play the most important role in explaining pragmatic disorders. In

addition, the observed influence of theory of mind on pragmatic ability was independent and not reducible to executive functions. It should be observed, however, that a large quote of variance remained unexplained, suggesting that pragmatic ability cannot be reduced to the use of other cognitive abilities. Neuroimaging studies have recently shown that an extended network is involved in pragmatic processing, whereby the key areas are localized in the fronto-temporo and temporo-parietal regions. These areas showed an abnormal neural activation in individuals with schizophrenia (e.g., Rapp et al., 2012; Rapp et al., 2013; Varga et al., 2013; Bosco et al., 2017b). While some of these areas, such as the temporo-parietal junction (TPJ), the medial prefrontal cortex (mPFC) and the dorsolateral prefrontal cortex (DLPFC), are generally associated with ToM and executive functions, others, such as the frontal inferior gyrus (IFG), the middle frontal gyrus (MFG) and the middle temporal gyrus (MTG), are more strictly associated with linguistic and pragmatic abilities (see Rapp, 2012, Jang, 2013).

Finally, as regards the pragmatic impairment observed on the extralinguistic scale of the ABaCo, the inclusion of ToM, as well as the addition of cognitive functions, did not contribute to an increase in the explained variance.

Before concluding, we would like to point out that only a limited number of patients took part in the study. A lager sample size is recommended, and empirical findings should be confirmed in further studies with a larger sample.

**Conclusions**

The results of the present investigation have shown that communicative-pragmatic impairment is a key deficit in schizophrenia and that some patients suffer from a pragmatic impairment without having other cognitive, i.e., ToM and EF deficits, This result should be borne in mind when planning rehabilitation therapies that should include specific programs focused on improving communicative-pragmatic problems (Bosco et al. 2016). We found that patients were severely impaired in their ability to communicate through non-verbal modalities, i.e., gestures and facial

expressions, as well as in the ability to communicate using linguistic/verbal means. Although there is no evidence to suggest that communicative impairment is associated with deficits in general cognitive functioning or executive functions, it has been found to be influenced by the patient's performance in theory of mind tasks on the linguistic scale of the ABaCo. However, theory of mind did not have a role in explaining patients' performance on the extralinguistic scale of the ABaCo. Finally, future studies should evaluate whether communicative-pragmatic impairment corresponds to an actual reduction in quality of life or poor social functioning of patients in everyday life.

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## Tables

Table 1 – Demographic and clinical data of patients with schizophrenia and healthy controls

| Variable | PATIENTS | | CONTROLS | |
|---|---|---|---|---|
| **Demographic data** | Mean | SD | Mean | SD |
| Age | 40.01 | 10.26 | 39.85 | 10.68 |
| Sex | 10.81 | 2.43 | 10.5 | 2.45 |
| Gender (M/F) | 21/5 | | 21/5 | |
| **Cut-off test** | | | | |
| MMSE | 27.37 | 1.83 | | |
| AAT | 114.81 | 5.45 | | |
| TOKEN | 5.88 | 0.33 | | |
| **Clinical measures** | | | | |
| Duration of illness | 15.69 | 8.1 | | |
| PANSS TOTAL | 48.64 | 19.38 | | |
| PANSS POSITIVE | 20.87 | 8.79 | | |
| PANNS NEGATIVE | 20.70 | 10.38 | | |

Table 2 - Mean and standard deviation of Linguistic and Extralinguistic scales in both comprehension and production subscales

| SCALE | PATIENTS | | CONTROLS | | | | CONFIDENCE INTERVALS 95% | |
|---|---|---|---|---|---|---|---|---|
| | MEAN | SD | MEAN | SD | *t* | *p* | Lower Bound | Upper Bound |
| Linguistic Comprehension | .72 | .20 | .90 | .09 | 4.06 | < .001 | .25 | .08 |
| Linguistic Production | .69 | 17 | .89 | .12 | 4.87 | < .001 | .28 | .11 |
| Extralinguistic Comprehension | .56 | 18 | .81 | .11 | 5.91 | < .001 | .33 | .16 |
| Extralinguistic Production | .58 | 21 | .82 | .15 | 4.72 | < .001 | .34 | .14 |

Table 3 – Mean and standard deviation of cognitive and theory of mind test

| COGNITIVE FUNCTIONS | TEST | PATIENTS | | CONTROLS | | T-value | Level of significance |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | | |
| SELECTIVE ATTENTION | *Attentive Matrices* | 37.12 | 8.15 | 48.72 | 6.04 | -5.82 | p < .001 |
| SPEED PROCESSING | *TMT A* | 57.96 | 22.56 | 31.0 | 15.13 | 4.89 | p < .001 |
| GENERAL INTELLIGENCE | *Raven Matrices* | 27.13 | 5.74 | 33.46 | 3.29 | -3.66 | P = .001 |
| WORKING MEMORY | *Verbal Span* | 3.46 | 0.72 | 4.23 | 0.95 | -3.28 | P = .002 |
| | *Visual Span* | 3.86 | 0.9 | 5.25 | 1.22 | -4.69 | P < .001 |
| COGNITIVE FLEXIBILITY | *TMT B-A* | 118.48 | 98.82 | 34.85 | 18.19 | 4.61 | P < .001 |
| INHIBITION | *Nelson* | 57.91 | 34.25 | 87.68 | 20.95 | -3.35 | P = .002 |
| THEORY OF MIND | *Smarties* | 88.46 | 32.58 | 100.0 | .0 | -1.81 | P = .077 |
| | *Sally_Ann* | 84.62 | 36.79 | 99.35 | 3.33 | -6.75 | P = .047 |
| | *Strange_Stories* | 63.18 | 22.70 | 95.46 | 8.97 | -6.75 | P < .001 |

| Pragmatic impairment | Cognitive deficits: PRESENT | ABSENT | TOTAL |
|---|---|---|---|
| PRESENT | 16 (61.5%) | 4 (15.4%) | 20 (76.9%) |
| ABSENT | 4 (15.4%) | 2 (7.7%) | 6 (23.1%) |
| TOTAL | 20 (76.9%) | 6 (23.1%) | 26 (100%) |

Table 4 – Contingency table of patients showing pragmatic impairment and cognitive deficits (i.e. general intelligence, selective attention, speed processing and EF deficits).

| Pragmatic impairment | Theory of mind deficits: PRESENT | ABSENT | TOTAL |
|---|---|---|---|
| PRESENT | 10 (38.4%) | 10 (38.4%) | 20 (76.9%) |
| ABSENT | 1 (3.8%) | 5 (19.2%) | 6 (23.1%) |
| TOTAL | 11 (42.3%) | 15 (57.7%) | 26 (100%) |

Table 5 – Contingency table of patients showing pragmatic impairment and theory of mind deficits