International Journal Dental and Medical Sciences Research
Volume 4, Issue 5, Sep-Oct 2022 pp 177-188 www.ijdmsrjournal.com ISSN: 2582-6018

The other side of social interaction: Impairments in theory of mind in people with Schizophrenia are linked to difficulty in understanding them by others.

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Submitted: 10-09-2022 Accepted: 20-09-2022

ABSTRACT:BACKGROUND: People suffering from schizophrenia (SZ) frequently exhibit problems in theory of mind (ToM) and speech output. While a link between ToM abilities and symptoms of thought disorder has been established, considerably less is known about other elements of speech output in SZ.

STUDY DESIGN: In this case-control study, 25 stable outpatients with recent-onset SZ (27.1 years, 22 men) and 22 matched healthy controls (25.6 years, 16 men) participated in a collaborative, verbal production task with a real interaction partner. Blind raters rated how easy it was for participants to comprehend them (Facility evaluations), how fascinating they were to listen to (Interest ratings), and how expressive they were (Expression ratings) (Expressivity ratings). The Combined Stories Test and Sarfati's cartoon assignment were used to evaluate ToM. The PANSS five-factor version was used to assess symptoms.

STUDY RESULTS:SZ obtained considerably lower scores for all three dimensions of their verbal performances (Facility, Interest, and Expressivity) when compared to healthy controls, despite the raters being blind to group membership. Interestingly, in the SZ group, Facility ratings were related to ToM performance, implying that SZ participants who have difficulty understanding others (ToM deficits) also make it difficult for others to understand them. Other interesting findings include a strong association between Expressivity and Interest ratings for both groups, as well as substantial correlations between Facility ratings and Cognitive/Disorganization symptoms, and Expressivity ratings with both Negative and Depression/Anxiety symptoms in SZ.

CONCLUSION: Studying speech production during genuine, collaborative social interactions may assist move beyond the individual approach to SZ deficiencies, allowing interaction partners to be involved in promoting more efficient communication for people with schizophrenia.

KEYWORDS: Discourse, Dialogue, Social interaction, Psychosis, Communication, Theory of mind

I. INTRODUCTION

People with schizophrenia (SZ) frequently present with Theory of mind (ToM) problems, which contribute to difficulties in daily functioning (Achim et al., 2013; Green et al., 2015; Sarfati et al., 1997; Savla et al., 2013). (Tshetiz et al., 2012; Fett et al., 2011; Thibaudeau et al., 2021). ToM is the ability to infer or portray other people's mental states, including their beliefs, knowledge, intentions, and emotions. While most studies targeting the impact of ToM on functioning in outpatients with schizophrenia have relied on overall measures of everyday functioning (Tshetiz et al., 2012; Bambini et al., 2016; Brüne et al., 2009; Cook et al., 2013; Jung et al., 2014; Langdon et al., 2014; Le et al., 2018; Weijers et al., 2018), evidence is starting to emerge suggesting that ToM deficits affect some areas of functioning more than others, namely the areas of functioning that involve collaborative social interactions with other people (i.e. shared goals; Tshetiz et al., 2022; Thibaudeau et al., 2021). The mechanisms through which ToM deficits translate into impaired social interactions however remain to be further examined. While it is reasonable to believe that the link between ToM abilities and SZ functioning is mediated by the ability to comprehend people during everyday social interactions (receptive part of communication), new data reveals that ToM is also engaged in the productive aspect of communication. We know from the literature in healthy people that effective communication necessitates tailoring one's linguistic output to the needs of the person receiving the message. (Tshetiz et al., 2015; Brennan et al., 2010; Clark and Wilkes-Gibbs, 1986; Horton and Gerrig, 2002; Isaacs and Clark, 1987).

Such changes in how speakers structure their verbal outputs are regarded to necessitate an

understanding of what constitutes common ground (i.e. shared knowledge) with the interaction partner. For example, if I say, "Jack was in a good mood this morning," the message is more ambiguous than if I say, "My son Jack was in a good mood this morning." A speaker who considers common ground (or lack thereof) makes it easier for the listener to understand their message.

Several studies have found such collaborative adjustments (taking shared ground into account) in healthy participants' speech productions into account) in the speech productions of healthy participants (Tshetiz et al., 2017; Tshetiz et al., 2015; Brennan et al., 2010; Brown-Schmidt, 2012; Fukumura and van Gompel, 2012; Fussell and Krauss, 1992; Heller et al., 2012; Horton and Gerrig, 2002; Knutsen and Le Bigot, 2012). Tshetiz et al. (2015) found a significant relationship between a psycho-metrically sound measure of ToM (the Combined stories task or COST; Tshetiz et al., 2012; Thibaudeau et al., 2018) and the ability to adjust one's speech during a collaborative interaction task, depending on the interlocutor's likely knowledge of the movie characters that the participants had to present. Participants were asked to offer a series of ten movie characters to their interlocutor, and they provided more detail to present the characters that the interlocutor was less likely to know (r = 0.47). While the study did not include a SZ group, it does imply that ToM deficiencies may be accompanied with difficulty in changing one's speech to ensure that the interlocutor is adequately understood during verbal encounters.

Speech production in SZ is frequently compromised (Tshetiz et al., 2012; Brüne et al., 2009; de Sousa et al., 2019; Docherty et al., 1996; Docherty et al., 2006; Green et al., 2015; Harvey, 1983), and these deficiencies have been shown using a variety of complimentary methodologies. People with schizophrenia, for example, may exhibit symptoms of mental disorder, which are actually abnormalities in language production considered to represent underlying chaotic thoughts (Andreasen, 1979a, Andreasen, 1979b; Kerns and Berenbaum, 2002). Evaluations of thought disorders are typically based on speech observed during clinical or research interviews, and subjective ratings are made using rating scales that can target either global thought disorder or a variety of specific aspects such as tangentially, derailment, incoherence, poverty of speech, and so on. The communication failure strategy, which focuses on unclarities in free speech (words or fragments for which the intended meaning is uncertain), has also identified speech production deficiencies in schizophrenia (Docherty, 2005; Docherty et al., 1996; Docherty et al., 2013; Docherty et al., 2006; Harvey, 1983). The CDI provides a framework and a validated scoring scheme for identifying all instances of communication failures (i.e., unclear meanings) in free speech samples and categorizing each event into one of six different categories (vague references, confused references, missing information references, ambiguous word meanings, wrong word references and structural unclarities). Several investigations utilizing the CDI found that patients with SZ had a higher rate of communication errors in their speech than healthy controls (Docherty, 2005; Docherty et al., 1996; Docherty et al., 2013; Docherty et al., 2006; Harvey, 1983). Finally, other studies relied on a linguistic approach, employing a variety of methods such as automated language analyzers (Elvevg et al., 2007; Minor et al., 2019) or manual coding of various linguistic features observed during language production tasks (e.g., choices of reference markers, linguistic alignment, etc.; Champagne-Lavau et al., 2009; Dwyer et al., 2020; Haas et al.

In addition to documenting poor speech output in SZ, some research investigated the relationship with ToM, with the great majority focusing on the relationship between ToM and thought disorder symptoms. A recent meta-analysis (de Sousa et al., 2019) summarised the research and found a strong relationship between ToM and global assessments of thought disorder (r = -0.35 across 57 studies). As a result, the association between ToM and thought disorder symptoms in SZ appears to be well established.In comparison, very fewer studies have examined the relationship between ToM and speech output in SZ using the other two approaches, either the communication failure strategy (targeting ambiguities in free speech samples) or the linguistic approach (targeting a range of linguistic features). However, such complementary approaches are crucial to explore since they allow for the examination of a broader variety of speech features and introduce far more regulated procedures for gathering speech samples. Docherty et al. (2013) conducted a study on the relationship between ToM and language output utilizing free speech samples (10 minutes, on topics such as interests, family, and so on) that were then scored with the communication disturbance index (CDI; Docherty et al., 1996). In that study, both outpatients with SZ (N = 63) and

their healthy control group (N = 21) had a significant association between the rate of communication failures identified with the CDI (total score) and ToM as assessed with the Hinting task (Corcoran et al., 1995) and Safarti's cartoon task (Sarfati et al., 2003). As far as we know, this was the only study that looked at the relationship between ToM and the rate of communication failures in SZ. In terms of the linguistic approach, some studies have begun to investigate various elements of language production in people with SZ during well-controlled social interaction tasks (Covington et al., 2005), with very few investigations focusing on the link with ToM. Champagne-Lavau et al. (2009) conducted one of the first studies to investigate that link, which included 31 SZ outpatients. The voice samples were created as part of a referential communication game in which participants discussed a succession of tangram images with the experimenter. To distinguish subgroups with greater or lower ToM performance on Sarfati's cartoon task (Sarfati et al., 2003), a median-split strategy was used, and the subgroup with lower ToM performance showed a less adapted use of indefinite versus definite references, i.e. they reintroduced previously mentioned items with indefinite references (e.g. "a mountain") instead of the expected definite references (e.g. "the mountain" Dwyer et al. (2020) investigated the relationship between ToM and alignment in dialogue, specifically the extent to which participants' descriptions were impacted by the experimenter's description in the preceding exchange. ToM was examined using a series of six scenarios that targeted first- and second-order false beliefs and deception, and their study found no significant relationship between ToM performance and alignment in a group of 42 SZ inpatients. Overall, relatively few investigations have looked beyond measurements of thought disorder to investigate the connection between ToM and speech production, and these previous studies used quite different methodologies to assess speech deficits and ToM. As a result, it is feasible that some linguistic aspects are highly linked to ToM (reference marker choices), while others (alignment) may be less affected by ToM deficits. Alternatively, the choice of ToM task (e.g., avoiding ceiling effects) or sample characteristics (e.g., outpatients versus inpatients) could alter the observed connections between variables of ToM and speech production.

Overall, the few research that rely on communication failure or the linguistic approach use organized approaches that can expand our understanding of the relationship between ToM and language production in SZ, but the literature is still quite restricted. Furthermore, several of the pioneer research' methodological decisions should be revisited. Docherty et al. (2013), for example, did not favour social interactions because the interviewer was present to encourage participants to speak but then listened without interacting with them. As a result, the evaluations were assigned to monologues rather than spoken dialogues. The studies conducted by Champagne-Lavau et al. (2009) and Dwyer et al. (2020) allowed for verbal exchanges, but they focused on very particular features of language creation and did not emphasize the success of the verbal communication act. Furthermore, the last two studies used ToM tasks, which frequently result in ceiling effects, making it difficult to show future connections with speech output (including Champagne-Lavau et al. (2009), which was confined to the use of a median split approach). As a result, we know relatively little about the relationship between ToM and language output in SZ in the setting of real-world social interactions in which people communicate with another person to achieve a common goal.

The current study sought to investigate the relationship between ToM and language produced in the setting of a collaborative interaction task. More precisely, we were curious about how easy or difficult it was to do a verbal collaborative task with people who had SZ (Facility ratings). In the sense that the focus is on the success of the communicative act, this is similar to the communication failure approach (looking at instances of unclarity in speech), but using a collaborative interaction task (similar to those typically used for the linguistic approach) makes it possible to standardised the discourse between participants and make the communication relevant to the attainment of a shared goal with another person, (i.e. help the interlocutor to reorder some image cards, see methods below). Our interaction task also gave us the opportunity to modify the effect of the interaction partner's likely prior knowledge of the content being addressed (movie scenes; see methods). This type of modification can teach us about the settings in which people with SZ's speech impairments are most noticeable. Furthermore, we investigated how intriguing and expressive participants were evaluated to be during the verbal cooperation exercise (Interest ratings and Expressivity ratings). This could provide a more complete knowledge of what interlocutors experience when verbally interacting with someone with SZ in real life, perhaps impeding social

International Journal Dental and Medical Sciences Research
Volume 4, Issue 5, Sep-Oct 2022 pp 177-188 www.ijdmsrjournal.com ISSN: 2582-6018

relationships if people with SZ were regarded less appealing during verbal exchanges.

II. METHODS

■ Participants

The study comprised 25 people with schizophrenia spectrum disorder (SZ; mean age = 27.1, 22 men), who were all recruited from a Gangtok City Hospital for first episode psychosis. The treating psychiatrist established the diagnoses of schizophrenia (N = 16), schizoaffective disorder (N = 7) and delusional disorder (N = 2) based on several sources of evidence such as clinical interviews, informant reports, and file reviews. The average duration of psychosis was 2.2 years (range 0.4-5.6; standard deviation = 1.4). At the time of testing, all SZ subjects were receiving an antipsychotic drug (see Table 1) and were stable outpatients.

Table 1: Socio-demographic characteristics, symptom ratings, theory of mind performance and number of movies from the experimental task that the participants had seen.

	SZ group	HC group	Statistics
Socio-demographic information			
Age	27.1 (4.8)	25.6 (5.9)	t(45) = 0.95, p = .349
Gender	22 M/3F	16 M/6F	X2 = 1.76, p = .184
Parental socio-economic category	3.5 (0.9)	3.2 (1.0)	t(45) = 1.18, p = .246
Estimated IQ	98.0 (6.1)	105.8 (11.4)	t(43) 2.86, p = .007

Symptoms	
PANSS Positive	14.3 (4.7)
PANSS Negative	15.5 (6.0)
PANSS cognitive/disorganization	9.3 (3.3)
PANSS depression/anxiety	8.1 (2.4)
PANSS excitation/hostility	5.6 (2.1)
PANSS total	60.2 (15.0)
PANSS P2: conceptual disorganization	2.0 (1.1)

Antipsychotic Medication	
Aripiprazole	N = 10
Olanzapine	N = 10
Quetiapine XR	N = 5
Clozapine	N = 3
Risperidone consta	N = 2
Risperidone	N = 2
Paliperidone palmitate	N = 1
Aripiprazole and quetiapine	N = 1

Other Medications	
Citalopram	N = 2
Mirtazapine	N = 2
Venlafaxine	N = 1
Lamotrigine	N= 5
Lithium	N = 1
Valproic acid	N = 1
Lorazepam	N = 6

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Clonazepam	N = 1

ToM Performance

ToM: COST (/52)	37.4 (8.0)	43.0 (4.8)	t(45) = −2.89, p = .006
ToM: Sarfati's Cartoon Task (/28)	24.4 (2.9)	26.2 (2.0)	t(45) = −2.46, p = .018

■ **Number of movies from the experimental task that the participants had seen.**

Total number (/6)	4.3 (1.4)	4.0 (1.3)	t(45) = 0.70, p = .490
Number of likely-known movies (/3)	2.6 (0.6)	2.6 (0.7)	t(45) = −0.42, p = .675
Number of likely-unknown movies (/3)	1.7 (1.1)	3 (1.0)	t(45) = 1.13, p = .263

Means are presented with standard deviations (SDs).

Twenty-two (22) healthy controls (HC) were recruited using local media advertisements and word-of-mouth. They were matched to the patients in terms of age and gender (mean age = 25.6; 16 men), as well as parental socioeconomic position (Miller, 1991). (see Table 1 for more details). If HC reported a mental diagnosis or were taking a psychoactive drug, they were excluded.

None of the subjects had a history of a neurological illness, and all had an estimated IQ in the normal range (i.e. 70 or higher) as measured by the WAIS-III Vocabulary and Block design sub-scales (Wechsler, 1997).

➢ **Collaborative interaction task and gullible judges' evaluations**

The current experiment is based on the referential communication paradigm, which replicates a communication scenario in which the participant must show a number of images to an interaction partner (Champagne-Lavau et al., 2009; Clark and Wilkes-Gibbs, 1986). In order to complete the task, participants were given six sets of six photos, each set depicting a different scenario from a film starring two men. The interaction partner, who was sitting on the opposite side of an opaque panel as shown in Fig. 1, carried the same six photos as the participant for each of the task's six trials, but on different cards and in a different order. In order for the interaction partner to follow the tale and arrange the images in the same order, participants were required to describe the movie scenario depicted on the photographs. Although participants in most prior referential communication studies were required to provide independent images on each task trial, this paradigm has also been successful in studying narrative discourse in a real but standardised communication context, as in the current study (Tshetiz et al., 2017; Fossard et al., 2018).

Fig. 1. Illustration of the collaborative interaction task.

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The task and materials were the same as those used by Tshetiz et al. (2017), and a validated manipulation was added so that three of the six movie scenes were from films that were likely known by the majority of Indian women in their twenties (corresponding to our research assistants serving as the interaction partner; likely-known condition), while the other three movie scenes were from films that a lesser percentage of women would know (likely-unknown condition). The interaction partner was free to ask questions or offer feedback when the participant presented the movie sequences during the activity. As the interaction partner, a qualified research assistant took part. The research assistant was trained to act as though she was unaware of all the likely unknown movies; for instance, she would ask for more information if a participant referred to a character from a likely unknown movie solely by his name. The research assistant was familiar with all the likely known movies.

Prior to beginning the activity, participants responded to a questionnaire asking if they had seen each of the six movies (**see Table 1**).

Each movie scene's dialogue was tape-recorded and divided into individual audio tracks. Then, each of the four undergraduate students listened to all the audio tracks (not knowing which ones were from SZ, HC or a control audio track; see Supplement S1).

As students listened to the story, they were instructed to:
(1) Arrange the visuals in sequence and note the order they arrived at.
(2) Rate the following three factors on a scale of 1 to 10.
2a) How difficult or simple was it to arrange the images? (Facility ratings).
2b) How compelling the narrative was (Interest ratings).
2c) The participant's voice's level of expression (Expressivity ratings).

- **Evaluation of the Theory of Mind**

The Combined Stories Test (COST; Tshetiz et al., 2012; Thibaudeau et al., 2018) and Sarfati's Cartoon Task were used to measure theory of mind (Sarfati et al., 2003). The COST is a tested story-based task that requires participants to read a number of stories and respond openly to inquiries about the characters' mental states. There are other examples and questions for control non-social reasoning. The COST displays favourable psychometric characteristics, such as high internal consistency, high test-retest reliability, and high inter-rater reliability (Tshetiz et al., 2012; Thibaudeau et al., 2018). Sarfati's cartoon assignment requires him to present three-image comic strips. Participants select from a collection of three additional photos the comic strip character's most likely next move for each comic strip.Although this task's psychometric features have not yet been established, it has been utilised in numerous previous research (Tshetiz et al., 2011; Sarfati and Hardy-Bayle, 1999; Sarfati et al., 1997) and was included in this study to evaluate ToM for non-verbal information.

- **Assessment of Symptoms**

The Positive and Negative Symptom Scale was used to score symptoms by the treating psychiatrists, who were unaware of the study's objectives or findings (PANSS; Kay et al., 1987). Given that it is better supported by earlier factor analyses (Lehoux et al., 2009), the five-factor version was chosen. These variables are: (a) positive symptoms; (b) negative symptoms; (c) cognitive/disorganization symptoms; (d) depression and anxiety; (e) excitement and anger (see Table 1).

- **Analyses**

The first step was to average the Facility, Interest, and Expressivity ratings across the four assessors and the six film sequences. Following that, these scores were put via independent-sample t-tests to check for between-group differences for each of the three ratings and Pearson Correlations to check for associations with theory of mind and the five PANSS symptoms categories in the SZ group. Additionally, the relationship with the PANSS's single conceptual disorganization rating (P2) was looked at. The correlations that arose between ToM performance and partial correlations that included non-social cognition as a control variable (non-social reasoning from the COST and estimated IQ, available for all SZ with the exception of two SZ) were then replicated.

The groups were also contrasted on both ToM scores using two-sample t-tests.

Additional exploratory analyses were also carried out to investigate potential impacts of the type of movie (presumably known or likely unknown) and potential impacts of the participants' movie viewing history (see additional information in Supplement S2).

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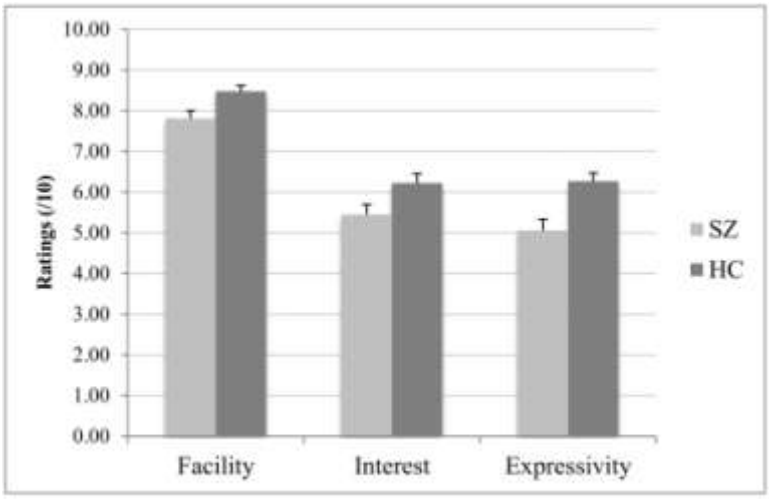
III. RESULTS

Between-Group Differences

As illustrated in Fig. 2, significant group differences were observed for the Facility ratings (t(45) = −2.68, p = .010, Effect size d (ESd) = 0.78), the Interest ratings (t(45) = −2.26, p = .029, ESd = 0.66) as well as the Expressivity ratings (t(45) = −3.47, p = .001, ESd = 1.01), with lower scores observed in SZ relative to HC.



SZ = Schizophrenia group; HC = Healthy controls

Fig. 2. Facility, Interest and Expressivity ratings (means and standard errors).

SZ = Schizophrenia group; HC = Healthy controls.

As presented in Table 1, SZ performed lower than HC on both ToM measures, namely the COST (t(45) = 2.89, p = .006, ESd = 0.86) and Sarfati's cartoon task (t(45) = 2.46, p = .018, ESd = 0.73).

➢ **Correlations with ToM and Symptoms**

In Table 2, the correlations are displayed. Both of the ToM tasks and the Facility ratings showed significant correlations in SZ (COST: r = 0.51; p =.010; Sarfati's task: r = 0.63; p =.001). When non-social cognition was taken into account, the association with Sarfati's task remained significant (r = 0.54, p =.018) whereas the link with the COST decreased (r = 0.38, p =.090).

Table 2. Correlations between the Facility Ratings, Interest ratings, Expressivity ratings and ToM as well as PANSS symptoms.

	Facility ratings	**Interest ratings**	**ToM-COST**	**ToM-sarfati**	**PANSS positive**	**PANSS negative**	**PANSS cognitive/desorg**	**PANSS depression/anxiety**	**PANSS excitation/hostility**	**PANSS P2 Conceptual disorganization**
Schizophrenia group										
Facility ratings			0.51□□	0.63□□	-0.07	-0.22	−0.51□□	−0.07	−0.24	-0.39
Interest ratings	−0.07		0.11	0.15	-0.21	-0.38	−0.04	-0.33	0.21	-0.03
Expressivity ratings	0.06	0.79□□	0.18	0.38	-0.30	−0.43□	-0.02	−0.53□□	0.14	-0.07

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Volume 4, Issue 5, Sep-Oct 2022 pp 177-188 www.ijdmsrjournal.com ISSN: 2582-6018

	Healthy Controls			
Facility ratings			0.03	-0.16
Interest ratings	0.14		-0.04	-0.14
Expressivity rating	0.44□	0.79□□	0.19	-0.11

□ **p < .05.** □□ **p < .001.**

A correlation also emerged between the Facility ratings and the Cognitive/Disorganization factor from the PANSS (r = −0.51, p = .010). The correlation between the Facility ratings and the single rating for Conceptual disorganization (PANSS P2) did not reach statistical significance (r = −0.39, p = .054).

For the Interest ratings, the only significant correlation in SZ was with the Expressivity ratings (r = 0.79, p < .001).

The Expressivity ratings were also significantly associated with Negative symptoms (r = −0.43, p = .033) and with Depression/Anxiety (r = −0.53, p = .006).

In HC, no association emerged between ToM and the three categories of ratings. The Facility ratings and the Interest ratings were however both significantly associated with the Expressivity ratings (Facility: r = 0.44, p = .041; Interest: r = 0.79, p < .001).

➢ **Additional analyses including the type of movie or familiarity with the movies**

As shown in Table 3, none of the interactions with group reached significance. A significant main effect of type of movie was observed for the Expressivity ratings (likely-known > likely-unknown movies) whereas a significant effect of Familiarity with the movie emerged for both the Interest ratings and Expressivity ratings (seen > not seen).

Table 3. Effect of type of movie and effect of familiarity with the movie (significant effects are highlighted in bold).

	ANOVAs including effect of type of movie			**ANOVAs including effect of familiarity with movie**		
	Group	**Type of movie**	**Interaction**	**Group**	**Familiarity with the movie**	**Interaction**
Facility ratings	F(1,45) = 7.16	F(1,45) = 0.01	F(1,45) = 2.21	F(1,35) = 6.75	F(1,35) = 0.97	F(1,35) = 1.48
	p = .010	p = .932	p = .144	p = .014	p = .332	p = .232
	ESd = 0.80	ESd = 0.03	ESd = 0.44	ESd = 0.87	ESd = 0.33	ESd = 0.41
Interests ratings	F(1,45) = 5.11	F(1,45) = 1.22	F(1,45) = 0.30	F(1,35) = 2.83	F(1,35) = 5.51	F(1,35) = 0.86
	p = .029	p = .275	p = .584	p = .101	p = .025	p = .361
	ESd = 0.67	ESd = 0.33	ESd = 0.16	ESd = 0.56	ESd = 0.78	ESd = 0.31
Expressivity ratings	F(1,45) = 12.02	F(1,45) = 8.30	F(1,45) = 0.57	F(1,35) = 7.09	F(1,35) = 5.16	F(1,35) = 0.24
	p < .001	p = .006	p = .454	p = .012	p = .029	p = .630
	ESd = 1.04	ESd = 0.86	ESd = 0.23	ESd = 0.89	ESd = 0.76	ESd = 0.16

As presented in Table 1, the groups did not significantly differ in terms of the number of movies that the participants had seen (t(45) = 0.70, p = .490).

IV. DISCUSSION

Verbal exchanges have a significant role in daily living. While it is obvious that individuals with SZ have deficiencies in ToM that prevent them from understanding others (the receptive part of social interactions), less is known about their capacity to effectively communicate during collaborative encounters (verbal production). In the current investigation, participants with SZ conducted a collaborative verbal interaction task based on the referential communication paradigm with an interaction partner. Following that, participants' verbal contributions were evaluated for their perceived interest and expressiveness as well as how easy they made it for the other person to complete the activity with them (Facility ratings) (Interest ratings and Expressivity ratings). Despite the raters being unaware of the existence or lack of a SZ diagnosis, SZ received lower scores than HC for all three characteristics of their verbal performances. Thus, rather than reflecting stigma or prejudice, the evaluations reflect traits seen in the speech samples. These group differences are crucial because they demonstrate that people with SZ have serious communication problems that other people with whom they interact can notice. The social contacts that persons with SZ have with their family and friends may make it especially necessary to take this into account. They may appear less expressive and therefore less interesting. Being more difficult for others to understand might undoubtedly have an effect on patients' daily lives as well as their clinical consultations, for instance by causing misconceptions that can occasionally cause friction in a relationship. Thus, it is especially important to have a deeper knowledge of the cognitive and clinical underpinnings of these challenges.

In SZ, the facility ratings and ToM performance—as measured by two separate ToM tasks—were related. This connection to ToM is crucial because it demonstrates how persons with SZ who have trouble understanding others also make it more difficult for others to understand them. This makes it more difficult for them to engage in constructive and successful interactions with others. Of course, we cannot assume the direction of the effect (for instance, that ToM influences language output), but it is still true that ToM and comprehension ability appear to be mutually impacted. As recovery is increasingly acknowledged as the preferred outcome, which entails connecting with others in the context of work, leisure, or other activities, it is of utmost importance to better understand these barriers to proper social connections in SZ. While up until now, the primary focus has been on the cognitive challenges that SZ patients themselves confront, an interaction-based approach opens the door to cognitive remediation therapies that address both the requirements of SZ patients and those of the others who interact with them. Building a shared understanding of the problem and communicating suitable directions to one another are necessary for working toward shared objectives with others. People with SZ who struggle to understand others (ToM deficiencies) or to communicate their ideas clearly to others (such as Facility ratings in the current study) should simply learn to check to see if they were clear before providing additional explanation if necessary. In terms of the friends, family, and coworkers of those with SZ, they might also receive more education regarding the challenges that these individuals can bring, enabling them to facilitate interactions by giving feedback on their own comprehension or seeking clarification when something is unclear.

The communication between patients and physicians during clinical consultations may be enhanced with a clearer understanding of these challenges. The relationship we found between Facility ratings and Cognitive/Disorganizational symptoms ($r = -0.51$) suggests that a quick assessment of these symptoms could alert clinicians to potential problems with their patients' ability to communicate effectively, which could prompt them to put strategies in place to address these roadblocks.

Although there was no statistically significant correlation between the Interest and Expressivity ratings and ToM or cognitive/disorganizational symptoms, there was a substantial correlation between them in SZ and HC. Even though participants were all delivering the same stories from the same movie sequences, this extremely strong association ($r = 0.79$ for both groups) shows that persons who are not particularly emotive when they tell a narrative are also seen as being less intriguing. In SZ, negative symptoms and symptoms of depression/anxiety were both substantially correlated with Expressivity ratings. Given that negative symptoms also contain an expressive component in addition to an experiencing component, the association with negative symptoms might have been anticipated (Blanchard and Cohen, 2006). Studies focusing on prosody in SZ also revealed a connection with low symptom ratings (Chakraborty et al., 2018). Our findings show that the diminished prosody associated with significant depression that was found in other investigations (Alpert et al., 2001)

also applies to the depression/anxiety symptoms seen in SZ.

This study makes the key finding that symptoms that are thought to lower patients' perceived Expressivity are also very likely to lower how fascinating they are perceived. This finding may have significant ramifications for patients in their day-to-day lives. Because of their lower level of Expressivity, people with SZ can be perceived as less intriguing by others, which would decrease their prospects for social contact. The observed findings emphasize the significance of taking into account the impact of patients' symptoms not only on their own personal activities and behaviour, but also on the relationships that they have with others, even though these implications would need to be examined more explicitly.

The tiny sample size and the fact that all of the subjects were taking medication at the time of the testing are the study's principal weaknesses. A larger sample size would have increased statistical power, but the effects seen in the current study were generally strong. The only effects that fell short of statistical significance were the partial correlation between ToM and the Facility ratings while controlling for non-social cognition and the relationship between the Facility ratings and thought disorder as measured by the PANSS item Conceptual disorganization. Thus, to enhance generalization, it could be interesting to repeat the current findings in a bigger sample and include a higher percentage of female participants. We also cannot rule out the possibility that the observed group differences on our various measures could have been caused by differences in medication status in addition to the differences in diagnosis status since the SZ group consisted solely of stable outpatients who were taking medication at the time of the testing. The fact that the participants worked on the collaborative assignment with a research assistant rather than a clueless interlocutor is another drawback. This made sure that the conversation partner always demonstrated a typical understanding of the movies. Confederates, however, can provide less natural feedback than would naive interlocutors, thus their use may have also affected the pattern of answers (Kuhlen and Brennan, 2013). Another drawback of this study is that it was exploratory in nature, therefore we did not account for multiple comparisons. As a result, due to the possibility of Type 1 error, the results should be interpreted cautiously.

Overall, this work provides a starting point for further research into collaborative interactions in SZ with a real interaction partner. It may be possible to develop a number of ways to enhance the interactions that people with SZ encounter in both their daily lives and during therapeutic consultations by looking beyond the challenges of the patients as a group.

- **Declaration of competing interest**

The Authors declares there is No any Conflict of Interests.

- **Supplementary Material**

Supplement S1. Additional information about the audio tracks

In order to keep the volunteers blind to the group to which the participants belong, the audio tracks were assigned random numbers, intermixing participants from both groups. In addition to the audio tracks from the participants, three additional audio tracks were also recorded in which volunteers who had not participated in the study narrated movie scenes based on the same six sets of six images, but organized in different orders than the order used for the actual participants. These audio-tracks were intermixed with those of the participants to ensure that the volunteers who listened to the audio tracks could not assume the same order for all the stories, hence requiring them to listen carefully to the stories to place the cards in order.

Supplement S2. Additional information on the exploratory analyses of type of movie and knowledge of the movie.

These exploratory analyses were performed to examine potential effects of the type of movie (likely-known or likely-unknown) and potential effects linked to whether the participants had seen the movies or not.

While it would have been interesting to examine the effect of these two variables concurrently, there were too few likely-known movies that the participants had not seen to allow such analyses. We hence examined the effect of the type of movie (likely-known or likely-unknown) across the three movies of each type (i.e. regardless of whether the participants had seen it or not), which was done using ANOVAs with group as the between subject-factor and Type of movie as the within subject factor. Similarly, we examined the effect of having seen the movie or not across both movie types, with was done with ANOVAs with group as the between subject-factor and Familiarity with the movie (seen or not) as the within subject factor. The participants who had seen all six movies (Ns = 6 SZ and 3 HC) could not be included in this last series of analyses.

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