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Language in schizophrenia: interpreting structural deficits

Linguagem na esquizofrenia: interpretando déficits estruturais

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ABSTRACT

This paper aims at offering an overview of the language anomalies observed in patients with schizophrenia, providing the diagnostic criteria of the disorder and a detailed characterization of linguistic issues observed. It focuses on grammar as a cognitive system of the mind, conceptualized as a computational mechanism responsible for weaving sound/sign and meaning together in a productive and optimal way. We present the linguistic deficits in morphology, syntax, semantics and pragmatics, while exploring the hypothesis that schizophrenia leads to diminution in grammar complexity. We also cover methods of data collection and analysis, including modern formal linguistic approaches and natural language processing (NLP) techniques. The discussed results indicate the potential role of language as a biomarker of schizophrenia, being particularly informative about how structure building is affected by the disorder.

KEYWORDS: Schizophrenia. Syntax. Semantics. Pragmatics. Morphology.

RESUMO

Este artigo tem como objetivo fornecer uma visão das anomalias de linguagem observadas em pacientes com esquizofrenia, provendo os critérios diagnósticos da desordem e uma caracterização detalhada das questões linguísticas observadas. Focando na gramática enquanto sistema cognitivo, entendido como mecanismo combinatorial responsável por tecer som/sinal e significado de maneira produtiva, apresentamos os déficits gramaticais de natureza morfológica, sintática, semântica e pragmática, explorando a hipótese de que a esquizofrenia leva a uma redução da complexidade gramatical. Trazemos, ainda, diferentes métodos de coleta e análise de dados, incluindo abordagens linguísticas formais modernas, técnicas de processamento de linguagem natural (PLN) e suas intersecções. Os resultados discutidos indicam o grande potencial da linguagem como biomarcador da esquizofrenia, sendo particularmente reveladores no que tange à estruturação gramatical frente à desordem.

PALAVRAS-CHAVE: Esquizofrenia. Sintaxe. Semântica. Pragmática. Morfologia.

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1. Introduction: characterization of schizophrenia

Schizophrenia (SZ) is a brain-based condition that produces chronic problems and abnormal behaviors, affecting people's ability to organize thoughts, to deal with emotions and to interact socially. The core symptoms of schizophrenia are characterized by several impairments causing difficulties in distinguishing what is real from what is not, and in forming coherent and complex ideas about oneself and the world (APA, 2013).

There is an agreement upon a very strong genetic component to the development of the SZ spectrum disorders; however, accumulating evidence suggests that SZ etiology involves complex combinations of several distinct factors including genetic, environmental, social, and psychological. Also, although the average age of onset ranges from late teens to early adulthood, incident cases may occur at all ages with marked differences in symptoms and social outcomes (Häfner, 2014). All of which makes it very hard to understand its cause and course. Likewise, the heterogeneous nature of SZ and the fact that the same patient might present a multiplicity of symptoms over different phases of the disorder contribute to the difficulty in reaching a diagnosis. Consequently, the diagnostic criterion of SZ is based on the presence or absence of different clinical symptoms and the degree of functional impairment exhibited by the patient, which is mostly observed through the patient's verbal behavior during clinical interviews (APA, 2013).

The World Health Organization (WHO) and the American Psychiatric Association (APA) provide diagnostic classification systems as guidelines to most diagnostic conditions in psychiatry, including SZ spectrum disorders. The latest versions of WHO and APA coding systems adopted a dimensional classification, which takes into consideration the degree to which a particular characteristic is present, and, although no final consensus about how to adequately describe major psychopathological dimensions of SZ was reached, a general agreement on relevant symptoms has been put forward, culminating in the characterization presented on figure 1.

Figure 1: Comparison between the diagnostic criteria of classification of the ICD-11 vs. the DSM-5.

ICD-11 (WHO) Schizophrenia and other primary psychotic disorders	**DSM-V (APA)** Schizophrenia spectrum and other primary psychotic disorders
For schizophrenia diagnosis, at least two of the following symptom categories are required to have been present for most of the time during a period of one month, or longer, one of which should be one of the core symptoms (a-d):	For schizophrenia diagnosis, two of the 5-key symptoms of psychotic disorders are required to be present for a significant portion of the time during a 1-month period, one of which should be of the core symptoms (a-c):
(a) persistent delusions (b) persistent hallucinations (c) disorganized thinking (d) distortions of self-experience (e.g., passivity phenomena, thought insertion or thought withdrawal) (e) negative symptoms (e.g., alogia, apathy and anhedonia) (f) psychomotor disorders	(a) delusions (b) hallucinations (c) disorganized speech (d) disorganized or catatonic behavior (e) negative symptoms

Source: Elaborated by the present authors.

Noteworthy, the symptoms of SZ are mainly grouped into three basic domains (or clusters): positive, negative, and disorganized. Positive symptoms (or core symptoms) are hallucinations, delusions, disorganized speech/disorganized thinking, and, as such, they manifest as an exacerbation of sensations, beliefs, and behaviors otherwise not observed in the control population. Contrastingly, negative symptoms manifest as a reduction or absence of traits often present in healthy individuals (e.g., flattened affect, anhedonia, alogia, lack of initiative). Disorganized symptoms are related to deficits in cognitive abilities, which, in SZ, manifest as disturbances of executive function, processing speed, memory, attention, and verbal fluency (Habtewold *et al*., 2019).

Since the first characterizations of SZ, disorganized and incoherent speech have been considered a central factor of the disorder and a reflex of a disruption in the associative processes of the mind connecting thought and reality (Bleuler, 1911). Although there is no perfect match between thought and language, it is argued that the patients' verbal behavior provides a window into their flow of thoughts (Andreasen, 1979a; Radanovic, 2013). So much so that, in the WHO and APA coding systems, disorganized speech and disorganized thinking symptoms are interchangeable, indicating that these are two sides of the same phenomena.

Currently, the symptoms of disorganized thinking/speech have been unified under the label of Formal Thought Disorder (FTD), which is conceptualized as a syndrome encompassing thought, language and communication disturbances (Andreasen, 1979a, 1979b, 1986; Andreasen; Grove, 1986 among others). FTD is characterized through the form and content of thought: (i) disorders of the content of thought, in which the content of the thought is disturbed, such as in delusions; and (ii) disorders of the form of thought, consisting of several abnormalities of language, such as anomalies in the logical sequencing of ideas, disturbances in the meaning of words and phrases, and lack of coherent meaning (see Covington *et al.*, 2005; Mckenna; Oh, 2005, among others). At clinical level, FTD can be further divided into positive FTD (+FTD) and negative FTD (-FTD). Symptoms of -FTD manifest as impoverishment of speech production (e.g., poverty of speech) or content (e.g., poverty of content); whereas symptoms of +FTD manifest as discourse disorganization (e.g., derailment, tangentiality, incoherence, illogicality) (Mckenna; Oh, 2005; Andreasen; Grove, 1986). It is, thus, patent that language is a central component of SZ.

The centrality of the language deficits to SZ is also investigated from an evolutionary point of view. Crow (2008) defends that both the disorder and the language capacity emerged from the same biological event that led to the segregation of the functional components of language between the two hemispheres, establishing a dominance of the left over the right hemisphere. In this model, the neural activities involved in language (production and comprehension) and thought spread asymmetrically, within the neurotypical brain, from one hemisphere to the other. Thus, according to Crow's hypothesis, the psychotic symptoms of SZ (i.e., delirium, hallucinations and FTD) reflect failures in specific convergence pathways responsible for thought planning, speech generation, speech perception and meaning, resulting in the psychotic symptoms being pictured as linguistic abnormalities.

Following Crow's hypothesis, Hinzen and Rosselló (2015) and Hinzen (2017) discuss the inner association between thought and language in the context of the disorder at hand. While acknowledging the traditional view of language as an expressive system dedicated to communication, the authors argue that disintegration of thought equals disintegration of language, taking language to be a cognitive system that mediates our species-specific form of rational thought. Therefore, disturbances in language bring about disruptions in thought processes, resulting in different symptoms depending on which component of the language architecture in the brain is affected.

Putting it all together, the main thread of reasoning is that the emergence of language in humans made us prone to SZ, which can actually reduce our language abilities. Thus, understanding the different linguistic profiles of SZ and identifying the subtle deviances in different aspects of language might provide a rich source of information in the search for biomarkers of the disorder, and may contribute to the theory about human brain evolution (Elvevåg *et al*., 2016; de Boer *et al*., 2020).

In this area of research, it is important to bear in mind that language is conceptualized as a biological/cognitive system, only found in humans, interfacing with other cognitive and mental abilities (Hauser; Chomsky; Fitch, 2002; Chomsky, 2006). Moreover, language is a self-contained system with no inherent reference or direct link to the outside world, consisting of internal combinatorial components – phonology, morphology, syntax, semantics and pragmatics.

Taking this into consideration, the present review provides a birds eye view of how SZ affects language. Unlike systematic reviews, this work fills the role of a scoping review, designed to offer a comprehensive, more flexible exploration of the linguistic findings associated with SZ that can establish a dialogue with formal linguistics frameworks. The studies included were selected based on relevance to the topic, their contribution to understanding language disruptions in SZ, and their publication in reputable journals. The selection process, while non-systematic, aimed to balance linguistic domains (e.g., morphology, syntax, pragmatics) to which empirical observations can be attributed. Finally, this is the starting stage of a systematic review with meta-analysis that is being conducted.

In section 2, a detailed description of linguistic anomalies in SZ is presented, separating them in two broad language levels: (i) semantic and pragmatic – related to the *content* of language; and (ii) syntactic and morphological – broadly associated with the *form* of language. In section 3, we summarize and discuss the results of the studies presented in section 2, extracting from them important generalizations. In section 4, a brief conclusion is presented.

2. Linguistic deficits in schizophrenia

2.1. Communication failures and impairments at the content level of language

One major work investigating communication failures in SZ was Rochester and Martin's (1979). They statistically analyzed and compared narrative samples from three groups of speakers (SZ with FTD (SZ+FTD), SZ without FTD (SZ-FTD), and subjects without schizophrenia (NSZ))

taken from clinical interviews, task-based interviews, and narrative and cartoon interpretation tasks. The study was based on the work of Halliday and Hasan (1976), which focuses on discourse cohesion within and between sentences that generate interpretation dependencies (e.g., coreference between pronouns and nouns). Their results revealed that the discourse of SZ showed general cohesion and referential impairments, with SZ+FTD producing a greater proportion of pronouns without reference, and SZ-FTD producing a higher proportion of full nominal expressions in opposition to pronouns. All of which indicate problems manifesting at the level of content of language.

Rochester and Martin's observations led to further investigations of communication problems in SZ. Special attention is given to Docherty and colleagues' works with the *Communication Disturbances Index* - CDI (Docherty *et al.*, 1996), which classifies six types of communication failure: confused references, missing information references, ambiguous word meanings, wrong word references, and structural unclarities. Statistical analysis was based on the frequencies of each communication failure found in the audiotaped transcripts, which were calculated dividing the number of instances of each anomaly by the amount of speech of a given interview sample. (1)-(3) present examples of the most common causes of communicative failures in SZ. In (1), the word *things* is overinclusive, causing the speech to be vague. In (2), the ambiguity between *George* and *Lester* as the referent of the 3Person pronoun makes the speech unclear. In (3), the lack of information regarding possible referents for the definite descriptions *the shops* and *the bakeries* leads to a communication failure.

(1) Being sick is, it's not bad. You can do *things* and plus you can make people afraid of you.

(2) I saw George and Lester at the store. *He* looked very sad.

(3) I like to work all right. Some of those shops were filth. I liked *the bakeries*, some of *the shops* are clean. (no prior mention of any shops or bakeries)

(Docherty *et al*., 1997, p. 502)

Docherty and Gottesman (2000) investigated interviews of monozygotic (i.e., identical) and dizygotic (i.e., fraternal) co-twins discordant for SZ. Their results show that, overall, co-twins with SZ produced higher levels of referential anomalies that culminated in communication failures, and that one type of failure in particular – missing information reference – distinguished between monozygotic and dizygotic co-twins without SZ.

All in all, these failures can be associated with difficulties at building linguistic overall meaning, revealing problems at the semantic and pragmatic levels of language, which are possibly the most easily noticed, due to the strong association between incoherency and the inability to match language and context in SZ (Ditman; Kuperberg, 2009). Recently, studies have reported on associations between pragmatic failures and Theory of Mind (ToM)[4]. Champagne-Lavau and Stip's (2010) work,

[4] Theory of Mind is a complex cognitive construct that involves understanding and attributing mental states to others while differentiating them from one's own. First-order ToM is associated with the ability to infer a person's mental states (e.g., thoughts, beliefs), whereas second-order ToM is associated with the ability to infer another person's mental states in relation to a third party. See Perner (1991), among others.

for example, tested 20 participants with SZ and 20 NSZ, native speakers of French. Participants were tested individually for three abilities: pragmatic (metaphor and indirect request comprehension), ToM (original first- and second order mental state attribution tasks) and executive functions (standardized neuropsychological tests of skills such as inhibition, set shifting, flexibility and verbal fluency). Results showed pragmatic impairments in SZ co-occurring with impaired executive functions (lack of flexibility) and ToM. Participants with SZ showed difficulties at interpreting sentences such as (4):

(4) Mon ami a le cœur gros.
"My friend has a heavy heart." (Champagne-Lavau; Stip, 2010, p. 289)

There is evidence that patients with SZ prefer denotative interpretations (in opposition to figurative expressions such as metaphors), neglecting figurative meaning and accepting more literal ones (see Brüne; Bodenstein, 2005; Kiang *et al*., 2007). Langdon *et al.* (2002) also reported failures in SZ related to judging the appropriateness of metaphoric and ironic utterances during a non-literal speech interpretation of statements derived from short stories. Titone *et al.* (2000) and Schettino *et al.* (2010) also found difficulties processing idiomatic expressions in SZ, with Titone *et al.* showing reduced comprehension for literally plausible idioms, and Schettino *et al.* reporting poorer performance, particularly with ambiguous idioms, linked to executive function deficits. Overall, pragmatic investigations mostly report metaphor comprehension deficits and preference for denotative/default meaning in SZ.

Studies adopting hand-tagging methodologies to analyze narratives were also informative of problems within building meaning in SZ. Çokal *et al*. (2018) compared narratives of 4 groups (15 SZ+FTD, 15 SZ-FTD, 15 (NSZ) 1st degree relatives of patients with SZ, and 15 NSZ). Statistical comparisons showed that SZ+FTD presented a significantly greater number of referential anomalies (e.g., vague references, anomalous 3Person pronouns) than NSZ. Sevilla *et al.* (2018) assessed the oral production of 3 groups of Spanish-Catalan native speakers (20 SZ+FTD, 20 SZ-FTD, 14 NSZ) in a task of recalling a fairytale. Their study found that referential anomalies in definite and pronominal NPs distinguished both groups of patients, and SZ+FTD from NSZ. Tovar Torres *et al.* (2019) examined interviews of 38 patients with SZ+FTD, all native speakers of Spanish. They found significantly more referential anomalies in 3Person pronouns (in opposition to 1Person and 2Person) and in null pronouns (in opposition to overt). Overall, these studies suggest a specific deficit in grammar-mediated forms of reference manifesting as communication failures.

Miranda e Silva (2022) adopted a formal syntactic approach with a manual syntactic and morphological tagging system to examine 78 Reddit posts (39 SZ, 39 NSZ) written in English. The following linguistic parameters were analyzed: (a) type of sentence: matrix [MS], and embedded [ES]; (b) type of truncation in function of anomalies, which depended on the recoverability of their contents and grammatical status: truncated anomalous [TS+A] vs. truncated non-anomalous [TS–A]; (c) subject or non-prepositioned object pronoun in function of phonological feature: overt [O] vs. null

[N]; (d) 3Person pronouns in function of referentiality: referential [3P+R] vs. expletive/generic reading [3P–R]; and (e) overt and null 3Person referential pronouns in function of referential anomaly: null anomalous [N3P+R+A] vs. overt anomalous [O3P+R+A]. When the referent of a specific 3Person pronoun was missing, unclear, or ambiguous, the pronoun was classified as anomalous.

(5) [...] About Me very monogamous currently a senior in university [^{MS} music is my passion], [^{MS} I^{O1P} listen to a wide range of genres, mostly older stuff] [^{MS} pro$^{N3P+R+A}$ loves discovering new music more than anything] [...]

About You: [$^{MS.TS-A}$ cute girl [^{ES} who is interested in a monogamous romantic relationship]] ([$^{MS.TS-A}$ would start online] but [^{MS} I^{O1P} expect us^{O1P} [^{ES} to meet up eventually]]) shorter and lighter than me ([^{MS} I^{O1P} am 6' and a healthy weight]) [^{MS} pro$^{N3P+R+A}$ has an interest in music, [^{ES} pro^{N3P-R} does not matter what genres] [$^{MS.TS+A}$ kind of needy/clingy]

(Miranda; Silva, 2022, p. 73)

In (5), pronominal anomalies are characterized by person feature shifts (e.g., the author starts writing in the 1Person and then makes a self-reference using the 3Person), which results in a communication failure. An anomalous sentential truncation is marked because there's a truncation of the external argument of the verb and the verb itself, but due to person feature shifts it's impossible to recover what is exactly deleted in the subject position. Miranda e Silva's results showed significantly more overt 3Person referential anomalous pronouns in SZ. The results confirm previous studies suggesting that content anomalies in SZ are mostly manifested as misuses of referential NPs.

In the sentential domain, the early work of Morice and McNicol (1986) showed significantly higher production of more semantically deviant sentences (unclear or bizarre in meaning) in SZ. They analyzed free speech samples of 3 groups (17 SZ, 17 subjects with Bipolar disorder (BP), and 19 NSZ). They also reported more dysfluency in SZ. Jo *et al*. (2023), in a more recent study, reported that native speakers of Korean with SZ produced significantly more semantically deviant sentences than NSZ.

In general, anomalies of the *content* of language are homogeneous crosslinguistically in SZ. Most studies report that patients with SZ have difficulty in metaphor comprehension and preference for denotative/default meanings[5]. Referential failures in the use of NPs are also consistently observed; especially 3Persons pronouns are the most common cause of communication failures in SZ. Semantically deviant sentences (e.g., sentences that are impossible to interpret) are also reported.

[5] Similar results were reported in Chaves and Rodrigues (2022), who conducted an experimental study investigating how schizotypal traits affect language. A significant preference for default meanings were observed in speakers with a high score on traits for constricted affect and unusual perceptual experiences. This is in accordance with a full-dimensional approach in which schizotypy is taken to be a broad continuum of multidimensional personality traits ranging from "normal" personality variations to SZ symptoms (Debbané; Barrantes-Vidal, 2015, among others).

2.2. Communication failures and impairments at the form level of language

Linguistic impairments of form of language in SZ encompass a range of abnormalities that affect structural aspects, particularly in syntax and morphology. Walenski *et al.* (2010) examined participants' (43 SZ, 42 NZS) ability to correctly fulfill morphological gaps of English verbs. Their results showed poor performance in SZ only in forming the past tense of regular verbs (e.g., dance → danced), with no significant effect for irregular verb forms (e.g., run → ran). The authors concluded that this result indicates procedural memory deficits in SZ. In other words, patients with SZ manifest difficulties in sustaining combinatorial grammatical processes that affect the morphological domain of language. Ziv *et al.* (2022) used computational methods to examine Hebrew oral narratives of 24 SZ and 25 NSZ. Their result showed a significantly lower ratio of inflection features (e.g., past tense). The authors interpret that, even though SZ can convey coherent meaning, they do so by using less complex morphology of language, which leads to the association of SZ with poor morphology.

At the syntactic level, studies in different languages have shown that SZ speakers have impoverished structure at the nominal and sentential level.

Morice and McNicol (1986) examined the length of speech production, number of dependent clauses, mean maximum depth to which dependent clauses were embedded and percentage of complex sentences. Their results showed significantly lower mean maximum depth of clausal embeddings and percentage of dependent reduced relative clauses in SZ. DeLisi (2001) analyzed oral productions of 2 groups (38 SZ, 12 NSZ) during a task of describing a series of pictures, reporting fewer embedded clauses in SZ. The author found that sentence complexity was familial and genetically linked with SZ within families. Çokal *et al*. (2018) reinforced these findings by reporting that the speech of SZ+FTD presented less syntactic complexity (e.g., lower rate of embedded sentences).

Chaves *et al*. (2023) observed significantly more matrix sentences and null pronouns in speakers of Brazilian Portuguese with SZ, which is interpreted as a tendency for producing simpler syntactic structures. Finally, although examining different languages, Miranda e Silva (2022) and Chaves *et al.* (2023) both reported a lower proportion of non-anomalous truncated sentences (i.e., grammatical ellipsis) in SZ. Their results were interpreted as indicative of diminished ability to apply the grammatical operation of ellipsis in SZ.

Moro *et al.* (2015) applied an acceptability judgment task, using a binary scale (Yes/No), to evaluate the syntactic knowledge of Italian native participants with SZ during a task of identification of syntax and semantics violations (see (6)) in long and short sentences, and also assessment of cognitive abilities. Results showed that SZ identified significantly less syntactic violations, presenting impaired performance for both long and short sentences. However, no correlation was observed between the results of the linguistics test and cognitive abilities. Thus, the authors concluded that the impaired grammatical knowledge of SZ is a linguistic specific condition.

(6) A chi scrivi prima di incontrare Ugo?
"To whom do you write before meeting Ugo?"
*Chi gli scrivi prima di incontrare?
"Who do you write to him before meeting?" (Moro *et al*., 2015, p. 151)

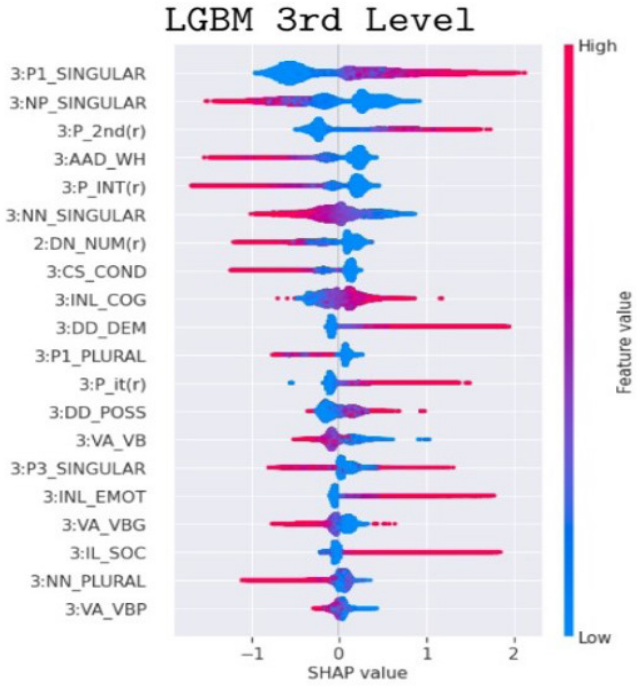
At the nominal level, studies showed that the system of reference in the language of SZ is most challenged towards its grammatical end, observed via a higher incidence of referential anomalies in definite NPs, which are grammatically mediated (Çokal *et al*., 2018; Sevilla *et al*., 2018; Çokal *et al*., 2023). Çokal *et al.* (2023), for example, investigated the distribution of referential noun phrases (NPs) in Turkish speakers by applying a picture description task to 16 SZ+FTD, 15 SZ-FTD and 27 NSZ. Their results revealed that SZ+FTD produced a higher incidence of bare NPs (without determiners) and null NPs, and a lower incidence of definite determiner phrases (DPs). The SZ-FTD group showed a similar pattern, but with less pronounced differences. The authors concluded that, since DPs are a type of structural nominal expression that specify the reference of a noun via definiteness, SZ affects it as it depends on grammar to be built.

Ziv *et al.*'s (2022) used an automatic syntactic parser to tag Hebrew oral productions. Their results showed significantly more 1Person pronouns and fewer 3Person pronouns in SZ. Tang *et al.* (2021) used a similar methodology to analyze transcribed open-ended interviews of 2 groups (20 SZ, 11 NSZ) using a part-of-speech (POS) tagger.[6] The authors found that greater production of 1Person pronouns ("I"), 2Person pronouns ("you"), filler words (e.g., "uh"), and incomplete words were distinctive of SZ. They also found significantly lower production of adverbs, adjectives, and determiners in SZ. Other studies made similar observations, reporting lower word count, greater production of pronouns and non-referential pronouns (e.g., expletive "it" and "there") were characteristic of SZ (Birnbaum *et al*. 2017; Bae *et al*., 2021, among others).

Computational methods applied to the investigation has provided a panoramic view of language in SZ by allowing automatic quantitative analyses of large corpora. Guerra (2023), for example, trained machine learning models to classify English Reddit posts into groups of individuals with self-reported SZ and a control group with no reports of SZ. Data was collected from the SZ subreddit and through web scraping tools, resulting in 408,791 posts: 151,320 SZ and 257,471 NSZ. The analysis involved three levels: lexical category, types of nouns, and person/number features applied to nouns and pronouns. These features were automatically extracted from texts via syntactic parsing techniques. The third level of features was the best at discriminating groups. The SHAP analysis generated from Guerra's work provides insightful clues to linguistic categories that are affected in SZ (see figure 3 and figure 4). SHAP is a method used to explain the output of the model by calculating the contribution of each feature to the predictions (in this case, of SZ).

[6] A POS tagger is a computational tool that automatically assigns grammatical labels (e.g., noun, verb, adjective) to linguistic elements, generally words, in a sentence.

Figure 3: SHAP plots of the contribution of each POS feature of the third set of features for the LightGBM model when predicting SZ.



The color represents the value of the feature (red indicates high feature values, and blue indicates low feature values).
Source: Guerra, 2023, p. 71.

Figure 4. Explanation of the terms in the SHAP plot as described by Guerra (2023)

Feature	Description	Examples
P1_SINGULAR	Singular 1st person pronouns	i; myself; my
NP_SINGULAR	Singular Proper Nouns	Mary; George; Australia
P_2nd(r)	2nd person pronouns	you; u; yours; urself
AAD_WH	Wh-Adverbs	when; where; why
P_INT(r)	Interrogative pronouns	who; whom; what
NN_SINGULAR	Singular Common Nouns	boy; pencils; hospital; trees
DN_NUM(r)	Numerals	one; 3; seventy
CS_COND	Conditional Subordinating Conjunctions	whether; if; unless
INL_COG	Cognitive Non-Lexical Interjections	;; ?; -
DD_DEM	Demonstrative Determiners	this; that; those
P1_PLURAL	Plural 1st person pronouns	we; us; ours; ourselves
P_it(r)	It pronouns	it; its; itself
DD_POSS	Possessive Determiners	my; your; her; its
VA_VB	Verb Base Form	go; stay; eat; fly
P3_SINGULAR	Singular 3rd person pronouns	he; her; himself; one
INL_EMOT	Emotional Non-Lexical Interjections	...; !
VA_VBG	Present Participle	going; doing
IL_SOC	Social Lexical Interjections	Wow!; dang; shoo; shh
NN_PLURAL	Plural Common Nouns	books; drivers; cars; cats
VA_VBP	Non-3rd Person Singular Present Verbs	want; need

Source: Elaborated by the authors.

To sum up, the linguistic impairment in SZ manifests itself across different linguistic domains, from semantics and pragmatics to syntax and morphology. Even though methodologies may vary, similar linguistic findings are observed across different arenas of research, from clinical interviews to linguistic judgment tasks and computational techniques. Also, the presented studies indicate that grammar of SZ shows impairments at the functional level, suggesting that SZ leads deficits at the functional information, resulting in impoverished structures and deviant meaning (see Tovar Torres *et al.*, 2019 for a similar suggestion). These deficits, depending on parametric variation, manifest differently, for example, in the use of anomalous null/overt pronominal forms.

3. Language in SZ: organizing what we know up to now

Language and thought disturbances are a hallmark of SZ. From Bleuler's early observations of illogical and incoherent speech to Andreasen's (1979a, 1979b) formative work categorizing speech disturbances in patients with SZ, researchers have consistently highlighted the complex interplay between the content and form of thought in this condition. Complementing this perspective, both Crow's (2008) and Hinzen and Rosselló's (2015) hypotheses emphasize the role of language as a cognitive system integral to rational thought. Moreover, Morice and McNicol's (1986) was the first to emphasize that syntactic impairments could be considered a trait rather than a state-dependent phenomenon of SZ, since they remained constant despite the varied symptomatology. Adopting the view of language as a combinatorial system (Hauser; Chomsky; Fitch, 2002; Chomsky, 2006), it has been argued that it might be the case that constraints on the syntactic structure of language might impose constraints on thought processes. In other words, limitations to the structuring of syntactic objects could result in impoverished thought content by restricting the form in which ideas are expressed. We are, thus, left with the question of whether language impairment in SZ is caused by deficits in other cognitive abilities, or the other way around.

From the viewpoint of Formal Linguistics, grammar is a cognitive system responsible for building structures that deliver referentiality and information about the world. Thus, when the propositional and referential functions of language fail, we might assume that the system responsible for correctly building them is broken. Here, the functional lexicon plays a crucial role by providing the formal features necessary for the scaffolding structures that support referentiality. These features mediate the grammatical relations between linguistic objects (e.g., the selection of a nominal argument by prepositions) (Rizzi; Cinque, 2016). Thus, alterations in the functional lexicon may result in alterations in how reference to propositions and entities is linguistically constructed. In SZ, it's observed that there are significant differences in how and which functional words are used. Studies presented here reported, for example, underuse of determiners (e.g., "the"), markers of definiteness in nominals, and complementizers, used to embed structures (Çokal *et al*., 2023; Guerra, 2023). These findings indicate that SZ affects syntax, being, thus, associated with an impoverishment of the combinatorial power of language.

The semantic and pragmatic anomalies manifested as the misuse of referential elements (e.g., anomalous Definite DPs and 3Person Referential Pronouns) and as the inability to match language and context (e.g., problems with irony and metaphors) can be interpreted as deficits at the structural level. Also, meaning problems caused by the decrease in grammatical complexity and increase in ungrammatical structures correlate with a reduced ability to express coherent meaning as the below narrative sample of a subject with SZ (Chaves, 2022, p. 120) shows:

Interviewer: Please, tell me this dream that you had?

Patient with SZ: (?) was (?). (?) explained (?). Once I was (?) when I lived in the village up there. I have lived there, alright. And then I heard (?). I liked to lay down outside in the balcony. I heard someone walking in slippers. Then, I stood up. (I) went home.

The majority of the sentences above are built out of simple (i.e., matrix independent sentences) and ungrammatical structures (i.e., truncated anomalous sentences). As indicated by (?), it is not possible to infer the missing arguments of the predicates headed by "was" and "explained". The second occurrences of "was" and "heard" are missing one of their arguments as well. Also, the meaning of the embedded clause "when I lived in the village up there" is compromised by the lack of a complete matrix clause. These truncations, together, obstruct the comprehension of what is being said.

Based on the evidence presented above, we argue that grammar in face of SZ is impaired at the syntactic level. This impairment is directly manifested as a preference for non-embedded matrix sentences and for weak, null pronominal forms, which have arguably less functional layers (Cardinaletti; Starke, 1994). Likewise, the reported inability of creating syntactic-semantics dependencies, such as those observed in A-bar movement, ellipsis, and binding, is a direct consequence of an impoverished syntax.

At the semantic level, the errors generated by syntactic deficits in SZ often result in ungrammatical sentences and linguistic constructions that are described as anomalous or bizarre in various studies (Rochester; Martin, 1979; Docherty *et al.*, 1997; Docherty; Gottesman, 2000, among others). For instance, when specificity conditions tied to the use of definite nominal expressions are not met (see example (3)), the resulting sentence fails to convey a fully coherent meaning (Hinzen; Sheehan, 2013). Similarly, truncation errors, such as incorrect use of ellipsis, hinder the recovery of the omitted structure, ultimately compromising the accessibility and clarity of the intended meaning. At the morphological level, results such as those of Walenski *et al.* (2010) show that SZ presents morphosyntactic problems, being unable to morphologically mark the Tense feature of the functional category T, selecting the wrong featural composition. These results highlight the role played by the computational system, since only regular verbs are affected by the observed difficulty.

At the pragmatic level, since syntax interacts with the Conceptual-Intentional system (Hauser; Chomsky; Fitch, 2002), the observed syntactic impoverishment leads to blockage and distortion of

the flow of information at the pragmatic level, making it harder for SZ speakers to resolve ambiguity, process figurative language (like metaphors) or draw inferences.

Noteworthy, there are reports of significant cognitive impairment across multiple ability domains in SZ (Mohamed *et al*., 1999; Dickinson *et al*., 2004 among others), such as ToM. However, since language is an integrative system it is expected that grammatical impairments will affect cognition as a whole. The development of ToM parallels the development of the ability to deal with complex syntactic structures, involving second order self-embeddings (de Villiers, 2000; de Villiers; Pyers, 2002, Hale; Tager-Flusberg, 2003, among others). Thus, ToM deficits in SZ is just another major consequence of the syntactic shortages observed in SZ. The same rationale applies to formal thought disorder (FTD): if thought is dependent on grammar to be structured (Hinzen, 2013, Hizen & Rosselló, 2015), unstructured thoughts (FTD) is equal to unstructured syntax.

Memory issues may play a critical role in the relationship between grammar and SZ, with evidence suggesting that various forms of memory impairments are linked to linguistic deficits in individuals with SZ. Studies have shown that both language production and comprehension in SZ are associated with deficits in executive functions and working memory (Docherty, 2005; Kerns, 2007). Specifically, patients with SZ exhibited difficulties in maintaining coherence across clauses, which can be attributed to memory dysfunctions (Ditman; Kuperberg, 2009). This lack of coherence is often seen when integrating multiple pieces of information, especially at critical points like the end of clauses, where patients rely more heavily on semantic memory instead of syntactic structures (Kuperberg; Kreher; Ditman, 2010). Walenski *et al.* (2010) argued that procedural memory, which supports grammatical structures, is affected in SZ, whereas declarative memory, which governs lexical knowledge, remains relatively intact. These findings reinforce the notion that memory dysfunctions, particularly procedural and working memory, contribute significantly to combinatorial shortages at the grammar level. However, the anomaly detection study conducted by Moro *et al.* (2015) found no clear correlation between syntactic impairments and working memory deficits in SZ. Their research demonstrated that, although SZ performed worse in identifying syntactic violations, this impairment could not be conclusively linked to working memory deficits. This result suggests that language disablement in SZ might not be the sole result of memory issues. Instead, the authors propose that language specifically is impaired in SZ. Hence, although working memory seems to be at play in SZ, we haven't been able to clearly detect how exactly it is affected, and, if it is, how it correlates with the linguistic issues amply attested in the disorder.

In our understanding, the discussion above indicates that in-depth research should center on formal analyses of grammar, and the analytical tools provided by theoretical Formal Linguistics can be efficiently used in investigations of this sort. Our current understanding of how functional and lexical information is put together to build meaning and reference and how the computational system of grammar deals with structural complexity is of great use. As we have shown above, studies conducted within current theoretical linguistics have successfully demonstrated that, independently

of the language, SZ leads to reductions in structural complexity, impairing the computational operations and/or the functional items necessary to build complex syntactic structures at the nominal and sentential level. In addition, as we have argued, if syntax interfaces with semantics, pragmatics, morphology and phonology, it is expected that failures at the syntactic level will affect all the other components of grammar. Therefore, by promoting in-depth investigations about syntax in SZ, we are expected to reach a better understanding of the language and cognitive deficits evidenced in SZ. Whether or not this is related to working memory is another issue that should be independently investigated, but again to investigate it we need a clear picture of how syntax is affected.

Conclusion

SZ is a mental dysfunction that shatters the patients' cognitive abilities, with language being majorly affected. The impacts of SZ on language are characterized by several impairments across the different components of grammar.

This paper highlights the importance of Formal Linguistics approaches, investigating how syntax is hindered. The studies reviewed above indicate that problems at the structural level, particularly at functional domains, lead to broader linguistics difficulties, at both LF and PF.

We also highlight the importance of interdisciplinary approaches in deepening our understanding of syndrome-specific language features, as evidenced by the relation of computational studies with Formal Linguistics findings, presented here. The interdisciplinary approaches contribute to the identification and differentiation of linguistic traits in individuals with SZ by providing different perspectives to observing the same phenomena.

Finally, the existing literature highlights the significant role of linguistic impairments in SZ. From Bleuler's early insights into disorganized speech to more recent theories positing language as an integral cognitive system, it is evident that syntactic deficits are a persistent and defining characteristic of the disorder, rather than a state-dependent phenomenon. These impairments manifest across various levels of linguistic structure, but are mainly concentrated in nominal (DP) and sentential (CP) functional categories. The several syntactic limitations observed in SZ constrain other cognitive processes, leading to anomalous thoughts and unexpected social behavior.

Future research should continue to refine our understanding of the syntax profiles of SZ, examining how impairments at this level are expressed across different languages and linguistic components.

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