Within-sample, but not corpus-based word frequency of verbal fluency output is associated with positive symptoms in schizophrenia

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Abstract

Previous research on word frequency during speech production in schizophrenia is scant and inconclusive. Furthermore, there may exist methodological difficulties in utilizing corpus-based word frequencies, while adequate corpora are not available for all languages. We calculated (1) corpus-based and (2) within-sample word frequencies of output on verbal fluency in 36 patients with schizophrenia and tested their associations with positive and negative symptoms. Within-sample word frequency was calculated as the number of subjects in the sample who produced the word. Within-sample but not corpus-based word frequencies displayed normal, non-skewed, and non-kurtic data distributions. Within-sample but not corpus-based word frequencies were significantly correlated with the severity of delusions and bizarre behavior. We propose that the within-sample word frequency might be a valuable alternative to corpus-based word frequencies in clinical research.

Keywords: applied linguistics; language disorder; neuropsychological assessment; language analysis; mental illness; word generation

Highlights

- Researchers typically rely on linguistic corpora when assessing word frequency.
- We propose a different method of calculating word frequency on speech production tasks.
- Positive symptoms were differentially associated with word frequencies on different word generation tasks.

1. INTRODUCTION[†]

[†] *Abbreviations:* LF = letter fluency, SANS = Scale for the Assessment of Negative Symptoms, SAPS = Scale for the Assessment of Positive Symptoms, SF = semantic fluency, VF = verbal fluency, WF = word frequency

The word frequency (WF) effect is one of the most robust phenomena observed in research on lexical processing (Brysbaert et al., 2011, 2018; Marino et al., 2020). For example, healthy subjects consistently exhibit quicker behavioral responses to high-frequency words compared to low frequency words on verbal tasks (e.g., Morrison & Ellis, 1995). Because patients with schizophrenia display diverse language and specifically lexical abnormalities (Baskak et al., 2008; Bora et al., 2019; Cavelti et al., 2018; Doughty & Done, 2009; Erdeljac & Sekulić Savić, 2019; Heim et al., 2019; Hinzen & Rosselló, 2015; Kircher et al., 2009, 2018; Krug et al., 2010; Kuperberg, 2010; Kuperberg & Caplan, 2003; Markov et al., 2009; Mendez, 2018; Nagels et al., 2011, 2016; Pawełczyk et al., 2018; Pomarol-Clotet et al., 2008; Tan et al., 2016), a plausible hypothesis is that they might exhibit abnormalities in the WF effect on lexical tasks.

In a verbal fluency (VF) task, the subject is asked to produce as many words as possible within a given time window (typically 60 s) in response to a given cue. Most often, the semantic (SF) and letter fluency (LF) tasks are used in which the subject is to name as many members of the given semantic category (e.g., *fruits*) or words beginning with the given letter/phoneme, respectively. Previous research on schizophrenia suggests that positive symptoms may be associated with qualitatively atypical word production on verbal fluency tasks, as indicated by clustering and semantic space analyses of the VF output (Allen et al., 1993; Aloia et al., 1996; Berberian et al., 2016; Berto & Galaverna, 2016; Kiang & Kutas, 2006; Paulsen et al., 1996; Pauselli et al., 2018; Piras et al., 2019; Popescu & Micluția, 2006; Popescu et al., 2007; Sumiyoshi et al., 2009; Sung et al., 2012; Tan et al., 2020, 2021). While several studies have reported that productivity on VF is negatively associated with negative (Allen et al., 1993; Docherty et al., 2011; Popescu & Micluția, 2006; Robert et al., 1998; Sumiyoshi et al., 2005; Veleva et al., 2019) and disorganization symptoms (Robert et al., 1998; Veleva et al., 2019), while only some studies reported that the quality of the VF output is also inversely associated with negative (Moore et al., 2006; Robert et al., 1998; Sumiyoshi et al., 2005) and disorganization symptoms (Pauselli et al., 2018; Robert et al., 1998) in schizophrenia. Despite the presence of qualitative abnormalities of the VF output in schizophrenia and their possible inverse association with the severity of psychotic symptoms, some studies have conflictingly suggested that patients with schizophrenia exhibit similar WF effects on lexical tasks compared to healthy subjects (Brébion et al., 2005; Rossell & Batty, 2008; Tan et al., 2016; but see Condray et al., 2010; Huron et al., 1995; Maher et al., 1983; Rossell & David, 2006). Additionally, Juhasz et al. (2012) compared frequencies of words produced on VF between

patients with schizophrenia and healthy subjects and found no significant differences, as well as no significant correlations between symptoms of disorganization and WF.

WFs are typically extracted from corpora. However, corpus-based WFs can be epistemologically problematic for the analysis of spoken word production (cf. Dash & Arulmozi, 2018a, b; Weigand, 2011). Firstly, corpora are usually constructed from written language data, often limited to particular text types, indicating they are rarely, if ever, adequately representative of natural language use. Secondly, natural word frequency is non-normally distributed, as most words have low frequencies, while a few words exhibit extremely high frequencies (Piantadosi, 2014). Thirdly, not all word forms, meanings, and uses can be documented in a single corpus, forcing researchers to paradoxically assign zero-value frequencies to some words (as if the words did not exist) or use other strategies such as removing the zero frequency words from analyses, thus affecting the outcome of the analyses (Brysbaert & Diependaele, 2013). Fourthly, corpora are not typically updated at (linguistically) short intervals, indicating they are in some degree diachronic (e.g., imagine the discrepancies in the frequencies of words like *virus*, *pandemic*, *mask*, etc. before and at specific intervals during the global response to COVID-19). Finally, adequately equipped corpora are not available for all languages of the world.

We propose for the purposes of VF research to also calculate the *within-sample word frequency*. This value corresponds to the number of subjects in the sample who produced the word. Arguably, this might deal with some of the limitations of corpus-based WF we have listed since (1) within-sample WF should be representative of language use in the given sample on the given task, (2) distribution should be normal or closer to normal as there are no extremely high frequencies, (3) zero frequency words are avoided, (4) synchronicity is ensured, and (5) dependence on annotated corpora is abolished. This might be of particular value to psychiatric research and practice given that a growing body of investigations suggests that specific linguistic analyses of patients' with schizophrenia verbal output might have a potential for use as diagnostic and/or predictive tools (Andreasen & Grove, 1986; Bearden et al., 2000; Bedi et al., 2015; Buck & Penn, 2015; Cohen et al., 2009; Corcoran et al., 2018; de Boer et al., 2020a, b; Foltz et al., 2016; Gupta et al., 2018; Iter et al., 2018; Mota et al., 2017; Rezaii et al., 2019; Rosenstein et al., 2015; Sabb et al., 2010; Sekulić Sović et al., 2019).

In the present study, we tested whether there is a relationship between the severity of positive and negative symptoms in patients with schizophrenia and the frequencies of the words produced on a semantic and letter fluency task. We analyzed both corpus-based and within-sample WFs and compared the results.

2. METHODS

2.1. Patients

Thirty-six German-speaking patients diagnosed with schizophrenia (F20.x) according to ICD-10 criteria (International Classification of Diseases; WHO, 1993) were included in the study. In- and outpatients were recruited and interviewed at the Department of Psychiatry and Psychotherapy, Philipps University of Marburg. All patients gave informed consent. Ethical approval was obtained by the Ethics Committee of the School of Medicine of the Philipps University of Marburg.

The severity of positive and negative symptoms were measured using the Scale for the Assessment of Positive Symptoms (SAPS) (Andreasen, 1984a) and Scale for the Assessment of Negative Symptoms (SANS) (Andreasen, 1984b), respectively. The dependent measures were the global scores and the subscale scores.

Table 1. Sociodemographic and clinical data for the patients ($n = 36$)

	Mean	SD	Range
Age (years)	37.89	11.32	21–65
Education (years)	10.14	1.64	8–13
Sex	9/36 females (25.0 %)		
SAPS	27.19	24.08	0–91
SANS	31.19	18.85	2–72

Note: SD = standard deviation, SAPS = Scale for the Assessment of Positive Symptoms, SANS = Scale for the Assessment of Negative Symptoms

2.2. Verbal fluency assessment

The semantic and letter fluency tasks were administered using the semantic category *animals* and the letter *p*, respectively. Patients were instructed to produce as many animal names, i.e., words beginning with the letter *p*, respectively. Time limit was set to 60 seconds. Output was audio-recorded, transcribed (ELAN, 2019; Wittenburg et al., 2006), and assessed according to Aschenbrenner et al. (2001). Every response in the output was assigned (1) a *corpus-based word frequency*, extracted from the German-language lexical database dlexDB (absolute frequency; Heister et al., 2011) and (2) a *within-sample word frequency*, calculated as the raw number of subjects who produced the word. For corpus-based WF, the median values for every patient were calculated, while the mean values were used for within-sample WF.

2.3. Statistics

Statistical analyses were conducted in SPSS (Version 25.0). Spearman's correlations were computed between (a) the global scores and subscale scores of the SAPS (Hallucinations, Delusions, Bizarre Behavior, and Positive Formal Thought Disorder) and SANS (Affective Flattening or Blunting, Alogia, Avolition–Apathy, Anhedonia–Asociality, and Inattentiveness), and (b) corpus-based and within-sample WFs. If a correlation with a subscale score was significant ($p < .05$), correlations with the individual symptoms within the subscale were further explored.

3. RESULTS

The descriptive data for the two word frequency variables (Table 2) show that corpus-based WF variables exhibited skewed, kurtic, and/or non-normal distributions. Contrastingly, within-sample WF variables displayed normal, non-skewed, and non-kurtic distributions.

Table 2. Descriptive data for the two word frequency variables

	Mean (SD)	Range	W	Skewness	Kurtosis
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corpus-based WF SF	753.000 (389.940)	164.5–1293	.005	-0.040	-1.416
within-sample WF SF	10.681 (2.274)	5.667–15.545	.479	0.283	0.081
corpus-based WF LF	483.667 (471.999)	17–2411	< .001	2.301	7.175
within sample WF LF	2.202 (0.634)	1–3.417	.587	-0.123	-0.750

Note: The p -value is reported from the Shapiro-Wilk test (abbreviated as W).
SD = standard deviation, W = Shapiro-Wilk test, WF = word frequency, SF = semantic fluency, LF = letter fluency

Correlations between the global and the four subscale scores of the SAPS, and the two word frequency variables are displayed in Table 3. There were no significant correlations between the symptom variables and corpus-based WF on either SF or LF.

Conversely, within-sample WF on SF was significantly negatively and weakly correlated with the global SAPS score ($r_s = -.348, p = .038$), as well as subscales measuring delusions ($r_s = -.391, p = .018$) and bizarre behavior ($r_s = -.332, p = .048$). After controlling for one or the other symptom variable, the significance of both correlations disappeared (delusions: partial $r_{s|Bizarre_behavior} = -.310, p = .070$, bizarre behavior: partial $r_{s|Delusions} = -.224, p = .195$). Subsequent analyses revealed that within-sample WF on SF was not significantly correlated with any of the individual delusional symptoms (highest r_s for delusions of being controlled, $r_s = -.325, p = .053$), while it was significantly negatively and moderately correlated with aggressive and agitated behavior ($r_s = -.433, p = .008$) within the bizarre behavior symptomatology.

Within-sample WF on LF was significantly positively and weakly correlated with the subscale measuring bizarre behavior of the SAPS scale ($r_s = .339, p = .043$) and specifically with aggressive and agitated behavior ($r_s = .341, p = .042$).

Table 3. Correlations between the global score and the four subscale scores of the SAPS, and the two word frequency variables

SAPS	Hallucinations	Delusions	Bizarre behavior	positive FTD
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corpus-based WF SF	$r_s = -.134$ $p = .435$	$r_s = -.249$ $p = .142$	$r_s = -.189$ $p = .270$	$r_s = -.137$ $p = .425$	$r_s = -.003$ $p = .985$
within-sample WF SF	$r_s = \mathbf{-.348}$ $p = \mathbf{.038*}$	$r_s = -.190$ $p = .268$	$r_s = \mathbf{-.391}$ $p = \mathbf{.018*}$	$r_s = \mathbf{-.332}$ $p = \mathbf{.048*}$	$r_s = -.221$ $p = .194$
corpus-based WF LF	$r_s = .257$ $p = .131$	$r_s = .017$ $p = .922$	$r_s = .302$ $p = .073$	$r_s = -.015$ $p = .932$	$r_s = .174$ $p = .309$
within-sample WF LF	$r_s = .184$ $p = .284$	$r_s = -.207$ $p = .225$	$r_s = .032$ $p = .854$	$r_s = \mathbf{.339}$ $p = \mathbf{.043*}$	$r_s = .215$ $p = .209$

Note: * $p < .05$

SAPS = global score from the Scale for the Assessment of Positive Symptoms, FTD = formal thought disorder, WF = word frequency, SF = semantic fluency, LF = letter fluency

There were no significant correlations between the two WF variables on both tasks and neither the SANS global score nor the five subscale scores.

4. DISCUSSION

The present study aimed to compare corpus-based and within-sample WFs and test whether there is a relationship between positive and negative symptoms, as well as particular subsyndromes in patients with schizophrenia and word frequencies. Comparing corpus-based within-sample WFs, we found that corpus-based WF variables exhibited skewed, kurtic, and/or non-normal distributions, whereas within-sample WF variables displayed non-skewed, non-kurtic, and normal distributions, indicating that different methodological frameworks may have better use of one or the other variable type. Without data transformation, parametric tests may be unsuitable for the analyses of corpus-based WF on VF.

Furthermore, significant correlations were observed only with the two within-sample WF variables. Our results suggest that the production of words of relatively lower frequencies on SF is associated with both the SAPS global score, as well as delusional and behavioral disorganization syndromes (bizarre behavior; specifically, aggressive and agitated behavior). Previous research has only found that disorganization symptoms are associated with VF performance (Robert et al., 1998; Veleva et al., 2019), although two other studies reported no significant association between

disorganization symptoms and VF performance (Docherty et al., 2011; Galaverna et al., 2014). Also, Juhasz et al. (2012) reported no significant correlations between disorganization symptoms and word frequency on VF. Additionally, previous studies have not reported associations between VF and bizarre behavior. Importantly, the observed associations were mostly weak.

Interestingly, there were disproportionate correlational directions across the SF and LF within-sample WFs, with higher bizarre behavior scores associated with lower within-sample WFs on SF but higher within-sample WFs on LF. Patients with higher levels of these symptoms appear to have exhibited a more efficient lexical access to relatively low-frequency words on SF but appeared to display a more restricted lexical access to relatively low-frequency words when an orthographically cued lexical search is underway (i.e., on LF). The discrepancy in the results is most likely tied to the assumption that subjects rely on the processing of two seemingly very different systems. In any case, we found a rather distinct pattern of word frequency effects on SF and LF in patients with schizophrenia in association with bizarre behavior, suggesting word frequency may represent a valuable tool in psychiatric research. However, future research should compare corpus-based and within-sample WFs of VF output between patients and healthy subjects to investigate whether patients with schizophrenia display abnormal word frequency patterns on VF.

Limitations – Firstly, we had no group of healthy subjects for comparison. Secondly, corpus-based and within-sample WFs differ in the sense that corpus-based WF is extracted from data on real language use in a presumably representative sample of speakers of a given language, while within-sample WF was calculated in our study from data of a behavior (i.e., VF) that is typically not observed during natural communication and using an unrepresentative sample of speakers of the given language. Thirdly, we did not control for multiple comparisons in our correlational analyses.

It can be concluded that within-sample WF may be more appropriate for analyzing VF output in psychiatric research or practice compared to corpus-based WF. Importantly, within-sample WF may also be used for the analyses of other linguistic tasks apart from VF, including discourse production (e.g., picture description).

Funding

This work was supported by the German Ministry for Education and Research (BMBF, grant number: 01UL1812X).

CRediT author statement

Petar Gabrić: Conceptualization, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Arne Nagels:** Writing - review & editing, Supervision. **Tilo Kircher:** Writing - review & editing, Supervision. **Anna Rosenkranz:** Formal analysis, Writing - review & editing, Supervision, Funding acquisition.

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