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Conference presentation / Izlaganje na skupu

https://doi.org/10.5281/zenodo.5616078

Support for a novel, simple method for calculating word frequency of output on language production tasks

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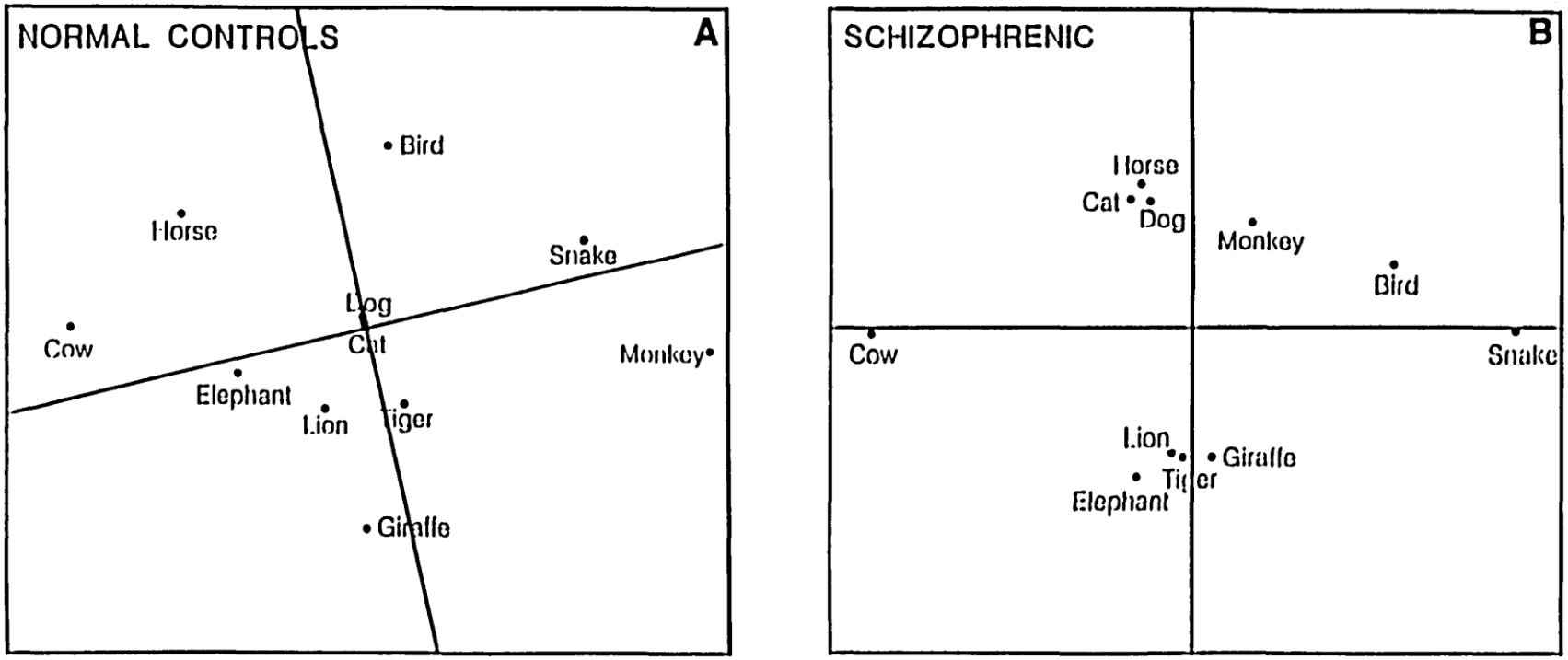
BACKGROUND
Language in schizophrenia

- Patients with schizophrenia (SCH) display diverse abnormalities in linguistic and specifically lexical processing

- Research using verbal fluency:
  - Reduced productivity
  - Atypical word clustering
  - Associations with psychotic symptoms

BACKGROUND
Language in schizophrenia



Aloia et al. (1996). *J. Int. Neuropsychol. Soc.* 2(4), 267–273. https://doi.org/10.1017/S1355617700001272

BACKGROUND
Word frequency (WF) effect in schizophrenia

- 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)

- Some obtained different results (Condray et al., 2010; Huron et al., 1995; Maher et al., 1983; Rossell & David, 2006)

- One study on word frequency on verbal fluency (Juhasz et al., 2012)

BACKGROUND
Corpus-based WF

- Corpora:
  - Usually constructed from written language data
  - Natural WF is non-normally distributed
  - Not all word forms, meanings, and uses can be documented in a single corpus
  - Corpora are not typically updated at (linguistically) short intervals
  - Adequately equipped corpora are not available for all languages of the world

AIMS OF THE STUDY
Corpus-based vs. within-sample word frequency

- We tested whether there is a relationship between the severity of positive and negative symptoms in patients with SCH and the frequencies of the words produced on two verbal fluency tasks

- Within-sample WF:
  - Representative of language use in the given sample on the given task
  - Distribution should be normal or closer to normal
  - Zero frequency words are avoided
  - Synchronicity is ensured
  - Dependence on annotated corpora is abolished

METHODS
Patients

- 36 German-speaking in- and outpatients diagnosed with schizophrenia (F20.x) according to ICD-10 criteria
- Symptom assessments: SAPS and SANS

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

METHODS
Verbal fluency

- Semantic fluency (SF): *animals*
- Letter fluency (LF): <p>

- 60 seconds

- Output was audio-recorded, transcribed (ELAN, 2019; Wittenburg et al., 2006), and assessed according to Aschenbrenner et al. (2001)

- Output was assigned: 1) a corpus-based WF (from dlexDB; Heister et al., 2011) and 2) a within-sample WF value

RESULTS & DISCUSSION
Descriptive data

Table 2. Descriptive data for the two word frequency variables

	Mean (SD)	Range	W	Skewness	Kurtosis
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

RESULTS & DISCUSSION
Descriptive data

- 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

RESULTS & DISCUSSION
Correlational analyses

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
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 = -.348** **p = .038***	r_s = -.190 p = .268	**r_s = -.391** **p = .018***	**r_s = -.332** **p = .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 = .339** **p = .043***	r_s = .215 p = .209

RESULTS & DISCUSSION
Correlational analyses

- Significant correlations were observed only with the two within-sample WF variables
- Previous research has only found that disorganization symptoms are associated with VF performance (Robert et al., 1998; Veleva et al., 2019)
- Disproportionate correlational directions across the SF and LF within-sample WFs
  - A distinct pattern of word frequency effects on SF and LF in patients with schizophrenia in association with bizarre behavior

LIMITATIONS

- We had no group of healthy subjects for comparison
- 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
- We did not control for multiple comparisons in our correlational analyses

THANK YOU FOR YOUR ATTENTION

Preprint available at: *PsyArXiv* (doi: 10.31234/osf.io/7tndz)

References

- Allen, H.A., Liddle, P.F., Frith, C.D., 1993. Negative features, retrieval processes and verbal fluency in schizophrenia. *Br. J. Psychiatry* 163(6), 769–775. https://doi.org/10.1192/bjp.163.6.769
- Aloia, M.S., Gourovitch, M.L., Weinberger, D.R., Goldberg, T.E., 1996. An investigation of semantic space in patients with schizophrenia. *J. Int. Neuropsychol. Soc.* 2(4), 267–273. https://doi.org/10.1017/S1355617700001272
- Andreasen, N., 1984a. *The Scale for the Assessment of Positive Symptoms (SAPS)*. University of Iowa, Iowa City.
- Andreasen, N., 1984b. *The Scale for the Assessment of Negative Symptoms (SANS)*. University of Iowa, Iowa City.
- Andreasen, N.C., Grove, W.M., 1986. Thought, language, and communication in schizophrenia: diagnosis and prognosis. *Schizophr. Bull.* 12(3), 348–359. https://doi.org/10.1093/schbul/12.3.348
- Aschenbrenner, S., Tucha, O., Lange, K.W., 2001. *RWT: Regensburger Wortflüssigkeits-Test*. Hogrefe – Verlag für Psychologie, Göttingen/Bern/Toronto/Seattle.
- Baskak, B., Ozel, E.T., Atbasoglu, E.C., Baskak, S.C., 2008. Peculiar word use as a possible trait marker in schizophrenia. *Schizophr. Res.* 103(1–3), 311–317. https://doi.org/10.1016/j.schres.2008.04.025
- Bearden, C.E., Rosso, I.M., Hollister, J.M., Sanchez, L.E., Hadley, T., Cannon, T.D., 2000. A prospective cohort study of childhood behavioral deviance and language abnormalities as predictors of adult schizophrenia. *Schizophr. Bull.* 26(2), 395–410. https://doi.org/10.1093/oxfordjournals.schbul.a033461
- Bedi, G., Carrillo, F., Cecchi, G.A., Slezak, D.F., Sigman, M., Mota, N.B., Ribeiro, S., Javitt, D.C., Copelli, M., Corcoran, C.M., 2015. Automated analysis of free speech predicts psychosis onset in high-risk youths. *npj Schizophr.* 1, 15030. https://doi.org/10.1038/npjschz.2015.30
- Berberian, A.A., Moraes, G.V., Gadelha, A., Brietzke, E., Fonseca, A.O., Scarpato, B.S., Vicente, M.O., Seabra, A.G., Bressan, R.A., Lacerda, A.L., 2016. Is semantic verbal fluency impairment explained by executive function deficits in schizophrenia?. *Rev. Bras. Psiquiatr.* 38, 121–126. https://doi.org/10.1590/1516-4446-2015-1663
- Berto, G., Galaverna, F.S., 2016. Semantic memory organization on verbal fluency test "Human Body Parts" in patients with chronic schizophrenia diagnosis and healthy controls. *Eur. J. Psychiatry* 30(2), 97–108. Retrieved from http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0213-61632016000200001
- Bora, E., Yalincetin, B., Akdede, B.B., Alptekin, K., 2019. Neurocognitive and linguistic correlates of positive and negative formal thought disorder: a meta-analysis. *Schizophr. Res.* 209, 2–11. https://doi.org/10.1016/j.schres.2019.05.025
- Brébion, G., David, A.S., Bressan, R.A., Pilowsky, L.S., 2005. Word frequency effects on free recall and recognition in patients with schizophrenia. *J. Psychiatr. Res.* 39(2), 215–222. https://doi.org/10.1016/j.jpsychires.2004.05.010
- Brysbaert, M., Buchmeier, M., Conrad, M., Jacobs, A.M., Bölte, J., Böhl, A. 2011. The word frequency effect: a review of recent developments and implications for the choice of frequency estimates in German. *Exp. Psychol.* 58, 412–424. https://doi.org/10.1027/1618-3169/a000123
- Brysbaert, M., Diependaele, K., 2013. Dealing with zero word frequencies: a review of the existing rules of thumb and a suggestion for an evidence-based choice. *Behav. Res. Methods* 45(2), 422–430. https://doi.org/10.3758/s13428-012-0270-5
- Brysbaert, M., Mandera, P., Keuleers, E., 2018. The word frequency effect in word processing: an updated review. *Curr. Dir. Psychol. Sci.* 27(1), 45–50. https://doi.org/10.1177/0963721417727521
- Buck, B., Penn, D.L., 2015. Lexical characteristics of emotional narratives in schizophrenia. *J. Nerv. Ment. Dis.* 203(9), 702–708. https://doi.org/10.1097/nmd.0000000000000354
- Cavelti, M., Kircher, T., Nagels, A., Strik, W., Homan, P., 2018. Is formal thought disorder in schizophrenia related to structural and functional aberrations in the language network? A systematic review of neuroimaging findings. *Schizophr. Res.* 199, 2–16. https://doi.org/10.1016/j.schres.2018.02.051
- Cohen, A.S., St-Hilaire, A., Aakre, J.M., Docherty, N.M., 2009. Understanding anhedonia in schizophrenia through lexical analysis of natural speech. *Cogn. Emot.* 23(3), 569–586. https://doi.org/10.1080/02699930802044651
- Condray, R., Siegle, G.J., Keshavan, M.S., Steinhauer, S.R., 2010. Effects of word frequency on semantic memory in schizophrenia: electrophysiological evidence for a deficit in linguistic access. *Int. J. Psychophysiol.* 75(2), 141–156. https://doi.org/10.1016/j.ijpsycho.2009.10.010
- Corcoran, C.M., Carrillo, F., Fernández-Slezak, D., Bedi, G., Klim, C., Javitt, D.C., Bearden, C.E., Cecchi, G.A., 2018. Prediction of psychosis across protocols and risk cohorts using automated language analysis. *World Psychiatry* 17(1),67–75. https://doi.org/10.1002/wps.20491
- Dash, N.S., Arulmozi, S., 2018a. *History, Features, and Typology of Language Corpora*. Springer, Singapore. https://doi.org/10.1007/978-981-10-7458-5
- Dash, N.S., Arulmozi, S., 2018b. Limitations of language corpora, in: Dash, N.S., Arulmozi, S., *History, Features, and Typology of Language Corpora*. Springer, Singapore, pp. 259–272. https://doi.org/10.1007/978-981-10-7458-5_15
- de Boer, J.N., Brederoo, S.G., Voppel, A.E., Sommer, I.E.C., 2020a. Anomalies in language as a biomarker for schizophrenia. *Curr. Opin. Psychiatry* 33(3), 212–218. https://doi.org/10.1097/yco.0000000000000595
- de Boer, J.N., van Hoogdalem, M., Mandl, R.C.W., Brummelman, J., Voppel, A.E., Begemann, M.J.H., van Dellen, E., Wijnen, F.N.K., Sommer, I.E.C., 2020b. Language in schizophrenia: relation with diagnosis, symptomatology and white matter tracts. *npj Schizophr.* 6, 10. https://doi.org/10.1038/s41537-020-0099-3
- Docherty, A.R., Berenbaum, H., Kerns, J.G., 2011. Alogia and formal thought disorder: differential patterns of verbal fluency task performance. *J. Psychiatr. Res.* 45(10), 1352–1357. https://doi.org/10.1016/j.jpsychires.2011.04.004
- Doughty, O.J., Done, D.J., 2009. Is semantic memory impaired in schizophrenia? A systematic review and meta-analysis of 91 studies. *Cogn. Neuropsychiatry* 14(6), 473–509. https://doi.org/10.1080/13546800903073291
- ELAN (Version 5.8), 2019. Max Planck Institute for Psycholinguistics, The Language Archive, Nijmegen. Retrieved from https://archive.mpi.nl/tla/elan
- Erdeljac, V., Sekulić Sović, M., (Eds.), 2019. *Interdisciplinary Linguistic and Psychiatric Research on Language Disorders*. FF Press, Zagreb. https://doi.org/10.17234/9789531758314
- Foltz, P.W., Rosenstein, M., Elvevåg, B., 2016. Detecting clinically significant events through automated language analysis: quo imus?. *npj Schizophr.* 2(1), 15054. https://doi.org/10.1038/npjschz.2015.54
- Gabrić, P., Nagels, A., Kircher, T., Rosenkranz, A., (2021a, April 17–21). *Psychiatric symptoms are differentially associated with verbal fluency performance in patients with schizophrenia and affective disorders* [Poster presentation]. 2021 Congress of the Schizophrenia International Research Society, Online, USA. https://doi.org/10.5281/zenodo.4675702
- Gabrić, P., Nagels, A., Kircher, T., Rosenkranz, A., (2021b). *Within-sample, but not corpus-based word frequency of verbal fluency output is associated with positive symptoms in schizophrenia* [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/7tndz
- Gabrić, P., Vandek, M., (2021). Semantic fluency reveals reduced functional connectivity between subcategorical co-hyponyms in recent-onset inpatients with first-episode psychosis. *Clin. Linguist. Phon.* [Latest Articles]. https://doi.org/10.1080/02699206.2021.1961019
- Galaverna, F.S., Morra, C.A., Bueno, A.M., 2014. Verbal fluency in chronic schizophrenia and severity of psychotic symptoms: consideration of their relationship with errors in the tasks. *Eur. J. Psychiatry* 28(3), 154–164. https://doi.org/10.4321/S0213-61632014000300003
- Gupta, T., Hespos, S.J., Horton, W.S., Mittal, V.A., 2018. Automated analysis of written narratives reveals abnormalities in referential cohesion in youth at ultra high risk for psychosis. *Schizophr. Res.* 192, 82–88. https://doi.org/10.1016/j.schres.2017.04.025
- Heim, S., Dehmer, M., Berger-Tunkel, M., 2018. Beeinträchtigungen von Sprache und Kommunikation bei Schizophrenie. *Nervenarzt* 90(5), 485–489. https://doi.org/10.1007/s00115-018-0647-5
- Heister, J., Würzner, K.-M., Bubenzer, J., Pohl, E., Hanneforth, T., Geyken, A., Kliegl, R., 2011. dlexDB – eine lexikalische Datenbank für die psychologische und linguistische Forschung. *Psychol. Rundsch.* 62, 10–20. https://doi.org/10.1026/0033-3042/a000029
- Hinzen, W., Rosselló, J., 2015. The linguistics of schizophrenia: thought disturbance as language pathology across positive symptoms. *Front. Psychol.* 6, 971. https://doi.org/10.3389/fpsyg.2015.00971
- Huron, C., Danion, J.M., Giacomoni, F., Grangé, D., Robert, P., Rizzo, L., 1995. Impairment of recognition memory with, but not without, conscious recollection in schizophrenia. *Am. J. Psychiatry* 152(12), 1737–1742. https://doi.org/10.1176/ajp.152.12.1737
- Iter, D., Yoon, J., Jurafsky, D., 2018. Automatic detection of incoherent speech for diagnosing schizophrenia, in: *Proceedings of the Fifth Workshop on Computational Linguistics and Clinical Psychology: From Keyboard to Clinic*. Association for Computational Linguistics, New Orleans, pp. 136–146. https://doi.org/10.18653/v1/w18-0615
- Juhasz, B.J., Chambers, D., Shesler, L.W., Haber, A., Kurtz, M.M., 2012. Evaluating lexical characteristics of verbal fluency output in schizophrenia. *Psychiatry Res.* 200, 177–183. https://doi.org/10.1016/j.psychres.2012.06.035
- Kiang, M., Kutas, M., 2006. Abnormal typicality of responses on a category fluency task in schizotypy. *Psychiatry Res.* 145(2–3), 119–126. https://doi.org/10.1016/j.psychres.2005.12.010
- Kircher, T., Krug, A., Markov, V., Whitney, C., Krach, S., Zerres, K., Eggermann, T., Stöcker, T., Shah, N.J., Treutlein, J., Nöthen, M.M., Becker, T., Rietschel, M., 2009. Genetic variation in the schizophrenia-risk gene neuregulin 1 correlates with brain activation and impaired speech production in a verbal fluency task in healthy individuals. *Hum. Brain Mapp.* 30(10), 3406–3416. https://doi.org/10.1002/hbm.20761

References

- Kircher, T., Bröhl, H., Meier, F., Engelen, J., 2018. Formal thought disorders: from phenomenology to neurobiology. *Lancet Psychiatry* 5(6), 515–526. https://doi.org/10.1016/s2215-0366(18)30059-2
- Krug, A., Markov, V., Krach, S., Jansen, A., Zerres, K., Eggermann, T., Stöcker, T., Shah, N.J., Nöthen, M.M., Georgi, A., Strohmaier, J., Rietschel, M., Kircher, T., 2010. Genetic variation in G72 correlates with brain activation in the right middle temporal gyrus in a verbal fluency task in healthy individuals. *Hum. Brain Mapp.* 32(1), 118–126. https://doi.org/10.1002/hbm.21005
- Krug, A., Nieratschker, V., Markov, V., Krach, S., Jansen, A., Zerres, K., Eggermann, T., Stöcker, T., Shah, N.J., Treutlein, J., Mühleisen, T.W., Kircher, T., 2010. Effect of CACNA1C rs1006737 on neural correlates of verbal fluency in healthy individuals. *NeuroImage* 49(2), 1831–1836. https://doi.org/10.1016/j.neuroimage.2009.09.028
- Kuperberg, G.R., 2010. Language in schizophrenia Part 1: an introduction. *Lang. Linguist. Compass* 4(8), 576–589. https://doi.org/10.1111/j.1749-818x.2010.00216.x
- Kuperberg, G., Caplan, D., 2003. Language dysfunction in schizophrenia, in: R.B. Schiffer, S.M. Rao, B.S. Fogel (Eds.), *Neuropsychiatry, Second Edition*. Lippincott Williams & Wilkins, Philadelphia [etc.], pp. 444–466. Retrieved from https://datascience.iq.harvard.edu/files/kuperberglab/files/kuperbergcaplan_neuropsych_2003.pdf
- Maher, B.A., Manschreck, T.C., Molino, M.A.C., 1983. Redundancy, pause distributions and thought disorder in schizophrenia. *Lang. Speech* 26(2), 191–199. https://doi.org/10.1177/002383098302600207
- Marino, C., Bernard, C., Gervain, J., 2020. Word frequency is a cue to lexical category for 8-month-old infants. *Curr. Biol.* 30(8), 1380–1386.e3. https://doi.org/10.1016/j.cub.2020.01.070
- Markov, V., Krug, A., Krach, S., Whitney, C., Eggermann, T., Zerres, K., Stöcker, T., Shah, N.J., Nöthen, M.M., Treutlein, J., Rietschel, M., Kircher, T., 2009. Genetic variation in schizophrenia-risk-gene dysbindin 1 modulates brain activation in anterior cingulate cortex and right temporal gyrus during language production in healthy individuals. *NeuroImage* 47(4), 2016–2022. https://doi.org/10.1016/j.neuroimage.2009.05.067
- Mendez, M.F., 2018. Non-neurogenic language disorders: a preliminary classification. *Psychosomatics* 59(1), 28–35. https://doi.org/10.1016/j.psym.2017.08.006
- Moore, D.J., Savla, G.N., Woods, S.P., Jeste, D.V., Palmer, B.W., 2006. Verbal fluency impairments among middle-aged and older outpatients with schizophrenia are characterized by deficient switching. *Schizophr. Res.* 87(1–3), 254–260. https://doi.org/10.1016/j.schres.2006.06.005
- Morrison, C.M., Ellis, A.W., 1995. Roles of word frequency and age of acquisition in word naming and lexical decision. *J. Exp. Psychol. Learn. Mem. Cogn.* 21(1), 116–133. https://doi.org/10.1037/0278-7393.21.1.116
- Mota, N.B., Copelli, M., Ribeiro, S., 2017. Thought disorder measured as random speech structure classifies negative symptoms and schizophrenia diagnosis 6 months in advance. *npj Schizophr.* 3(1), 18. https://doi.org/10.1038/s41537-017-0019-3
- Nagels, A., Kirner-Veselinovic, A., Krach, S., Kircher, T., 2011. Neural correlates of S-ketamine induced psychosis during overt continuous verbal fluency. *NeuroImage* 54(2), 1307–1314. https://doi.org/10.1016/j.neuroimage.2010.08.021
- Nagels, A., Fährmann, P., Stratmann, M., Ghazi, S., Schales, C., Frauenheim, M., Turner, L., Hornig, T., Katzev, M., Müller-Isberner, R., Grosvald, M., Krug, A., Kircher, T., 2016. Distinct neuropsychological correlates in positive and negative formal thought disorder syndromes: the Thought and Language Disorder Scale in endogenous psychoses. *Neuropsychobiology* 73(3), 139–147. https://doi.org/10.1159/000441657
- Pauselli, L., Halpern, B., Cleary, S.D., Ku, B., Covington, M.A., Compton, M.T., 2018. Computational linguistic analysis applied to a semantic fluency task to measure derailment and tangentiality in schizophrenia. *Psychiatry Res.* 263, 74–79. https://doi.org/10.1016/j.psychres.2018.02.037
- Paulsen, J.S., Romero, R., Chan, A., Davis, A.V., Heaton, R.K., Jeste, D.V., 1996. Impairment of the semantic network in schizophrenia. *Psychiatry Res.* 63(2–3), 109–121. https://doi.org/10.1016/0165-1781(96)02901-0
- Pawełczyk, A., Kotlicka-Antczak, M., Łojek, E., Ruszpel, A., Pawełczyk, T., 2018. Schizophrenia patients have higher-order language and extralinguistic impairments. *Schizophr. Res.* 192, 274–280. https://doi.org/10.1016/j.schres.2017.04.030
- Piantadosi, S.T., 2014. Zipf's word frequency law in natural language: a critical review and future directions. *Psychon. Bull. Rev.* 21(5), 1112–1130. https://doi.org/10.3758/s13423-014-0585-6
- Piras, F., Piras, F., Banaj, N., Ciullo, V., Vecchio, D., Edden, R.A.E., Spalletta, G., 2019. Cerebellar GABAergic correlates of cognition-mediated verbal fluency in physiology and schizophrenia. *Acta Psychiatr. Scand.* 139(6), 582–594. https://doi.org/10.1111/acps.13027
- Pomarol-Clotet, E., Oh, T.M.S.S., Laws, K.R., McKenna, P.J., 2008. Semantic priming in schizophrenia: systematic review and meta-analysis. *Br. J. Psychiatry* 192(2), 92–97. https://doi.org/10.1192/bjp.bp.106.032102
- Popescu, C.A., Micluţia, I.V., 2006. Semantic fluency in schizophrenia. *J. Evid.-Based Psychot.* 6(2), 105–118. http://jebp.psychotherapy.ro/vol6no2/semantic-fluency-in-schizophrenia/
- Popescu, C.A., Miclutia, I.V., Macrea, R., Craciun, I., Zaharia, A., 2007. Semantic fluency in schizophrenia. *Eur. Psychiatry* 22, S133. https://doi.org/10.1016/j.eurpsy.2007.01.426
- Rezaii, N., Walker, E., Wolff, P., 2019. A machine learning approach to predicting psychosis using semantic density and latent content analysis. *npj Schizophr.* 5, 9. https://doi.org/10.1038/s41537-019-0077-9
- Robert, P.H., Lafont, V., Medecin, I., Berthet, L., Thauby, S., Baudu, C., Darcourt, G., 1998. Clustering and switching strategies in verbal fluency tasks: comparison between schizophrenics and healthy adults. *J. Int. Neuropsychol. Soc.* 4(6), 539–546. https://doi.org/10.1017/S1355617798466025
- Rosenstein, M., Foltz, P.W., DeLisi, L.E., Elvevåg, B., 2015. Language as a biomarker in those at high-risk for psychosis. *Schizophr. Res.* 165(2–3), 249–250. https://doi.org/10.1016/j.schres.2015.04.023
- Rossell, S.L., David, A.S., 2006. Are semantic deficits in schizophrenia due to problems with access or storage?. *Schizophr. Res.* 82(2–3), 121–134. https://doi.org/10.1016/j.schres.2005.11.001
- Rossell, S.L., Batty, R.A., 2008. Elucidating semantic disorganisation from a word comprehension task: do patients with schizophrenia and bipolar disorder show differential processing of nouns, verbs and adjectives?. *Schizophr. Res.* 102(1–3), 63–68. https://doi.org/10.1016/j.schres.2008.04.008
- Sabb, F.W., van Erp, T.G.M., Hardt, M.E., Dapretto, M., Caplan, R., Cannon, T.D., Bearden, C.E., 2010. Language network dysfunction as a predictor of outcome in youth at clinical high risk for psychosis. *Schizophr. Res.* 116(2–3), 173–183. https://doi.org/10.1016/j.schres.2009.09.042
- Sekulić Sović, M., Erdeljac, V., Kužina, I., 2019. Do shared semantic features facilitate lexical-semantic processing in early course psychosis?. *Clin. Linguist. Phon.* 34(4), 357–365. https://doi.org/10.1080/02699206.2019.1650831
- Sumiyoshi, C., Sumiyoshi, T., Nohara, S., Yamashita, I., Matsui, M., Kurachi, M., Niwa, S., 2005. Disorganization of semantic memory underlies alogia in schizophrenia: an analysis of verbal fluency performance in Japanese subjects. *Schizophr. Res.* 74(1), 91–100. https://doi.org/10.1016/j.schres.2004.05.011
- Sumiyoshi, C., Ertugrul, A., Yagcioglu, A.E.A., Sumiyoshi, T., 2009. Semantic memory deficits based on category fluency performance in schizophrenia: similar impairment patterns of semantic organization across Turkish and Japanese patients. *Psychiatry Res.* 167(1–2), 47–57. https://doi.org/10.1016/j.psychres.2007.12.009
- Sung, K., Gordon, B., Vannorsdall, T.D., Ledoux, K., Pickett, E.J., Pearlson, G.D., Schretlen, D.J., 2012. Semantic clustering of category fluency in schizophrenia examined with singular value decomposition. *J. Int. Neuropsychol. Soc.* 18, 565–575. https://doi.org/10.1017/S1355617712000136
- Tan, E.J., Yelland, G.W., Rossell, S.L., 2016. Characterising receptive language processing in schizophrenia using word and sentence tasks. *Cogn. Neuropsychiatry* 21(1), 14–31. https://doi.org/10.1080/13546805.2015.1121866
- Tan, E.J., Wagner, G.A., Rossell, S.L., 2016. Examining lexical processing with two word tasks using the schizotypy analogue. *Psychiatry Res.* 246, 293–295. https://doi.org/10.1016/j.psychres.2016.09.048
- Tan, E.J., Neill, E., Tomlinson, K., Rossell, S.L., 2020. Semantic memory impairment across the schizophrenia continuum: a meta-analysis of category fluency performance. *Schizophr. Bull. Open* 1(1), sgaa054. https://doi.org/10.1093/schizbullopen/sgaa054
- Tan, E.J., Neill, E., Tomlinson, K., Rossell, S.L., 2021. Corrigendum to: Semantic memory impairment across the schizophrenia continuum: a meta-analysis of category fluency performance. *Schizophr. Bull. Open* 2(1), sgab018. https://doi.org/10.1093/schizbullopen/sgab018
- Veleva, I.I., Stoimenova, M.J., Valkova, M.P., 2019. A comparative study of verbal fluency in patients with paranoid schizophrenia, first grade relatives and healthy controls. *Arch. Balk. Medical Union* 54(2), 325–329. https://doi.org/10.31688/ABMU.2019.54.2.16
- Weigand, E., 2011. Possibilities and limitations of corpus linguistics, in: Aijmer, K. (Ed.), *Dialogue Analysis VIII: Understanding and Misunderstanding in Dialogue*. Max Niemeyer Verlag, Berlin/New York, pp. 301–318. https://doi.org/10.1515/9783110933239.301
- WHO (World Health Organization), 1993. *The ICD-10 Classification of Mental and Behavioural Disorders: Clinical Descriptions and Diagnostic Guidelines*. World Health Organization, Geneva. Retrieved from https://www.who.int/classifications/icd/en/bluebook.pdf
- Wittenburg, P., Brugman, H., Russel, A., Klassmann, A., Sloetjes, H., 2006. ELAN: a professional framework for multimodality research, in: Calzolari, N., Choukri, K., Gangemi, A., Maegaard, B., Mariani, J., Odijk, J., Tapias, D. (Eds.), *Proceedings of the Fifth International Conference on Language Resources and Evaluation (LREC'06)*. European Language Resources Association (ELRA), Genoa, pp. 1556–1559. Retrieved from http://www.lrec-conf.org/proceedings/lrec2006/pdf/153_pdf.pdf

References

Allen, H.A., Liddle, P.F., Frith, C.D., 1993. Negative features, retrieval processes and verbal fluency in schizophrenia. *Br. J. Psychiatry* 163(6), 769–775. https://doi.org/10.1192/bjp.163.6.769

Aloia, M.S., Gourovitch, M.L., Weinberger, D.R., Goldberg, T.E., 1996. An investigation of semantic space in patients with schizophrenia. *J. Int. Neuropsychol. Soc.* 2(4), 267–273. https://doi.org/10.1017/S1355617700001272

Andreasen, N., 1984a. *The Scale for the Assessment of Positive Symptoms (SAPS)*. University of Iowa, Iowa City.

Andreasen, N., 1984b. *The Scale for the Assessment of Negative Symptoms (SANS)*. University of Iowa, Iowa City.

Andreasen, N.C., Grove, W.M., 1986. Thought, language, and communication in schizophrenia: diagnosis and prognosis. *Schizophr. Bull.* 12(3), 348–359. https://doi.org/10.1093/schbul/12.3.348

Aschenbrenner, S., Tucha, O., Lange, K.W., 2001. *RWT: Regensburger Wortflüssigkeits-Test*. Hogrefe – Verlag für Psychologie, Göttingen/Bern/Toronto/Seattle.

Baskak, B., Ozel, E.T., Atbasoglu, E.C., Baskak, S.C., 2008. Peculiar word use as a possible trait marker in schizophrenia. *Schizophr. Res.* 103(1–3), 311–317. https://doi.org/10.1016/j.schres.2008.04.025

Bearden, C.E., Rosso, I.M., Hollister, J.M., Sanchez, L.E., Hadley, T., Cannon, T.D., 2000. A prospective cohort study of childhood behavioral deviance and language abnormalities as predictors of adult schizophrenia. *Schizophr. Bull.* 26(2), 395–410. https://doi.org/10.1093/oxfordjournals.schbul.a033461

Bedi, G., Carrillo, F., Cecchi, G.A., Slezak, D.F., Sigman, M., Mota, N.B., Ribeiro, S., Javitt, D.C., Copelli, M., Corcoran, C.M., 2015. Automated analysis of free speech predicts psychosis onset in high-risk youths. *npj Schizophr.* 1, 15030. https://doi.org/10.1038/npjschz.2015.30

Berberian, A.A., Moraes, G.V., Gadelha, A., Brietzke, E., Fonseca, A.O., Scarpato, B.S., Vicente, M.O., Seabra, A.G., Bressan, R.A., Lacerda, A.L., 2016. Is semantic verbal fluency impairment explained by executive function deficits in schizophrenia?. *Rev. Bras. Psiquiatr.* 38, 121–126. https://doi.org/10.1590/1516-4446-2015-1663

Berto, G., Galaverna, F.S., 2016. Semantic memory organization on verbal fluency test "Human Body Parts" in patients with chronic schizophrenia diagnosis and healthy controls. *Eur. J. Psychiatry* 30(2), 97–108. Retrieved from http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0213-61632016000200001

Bora, E., Yalincetin, B., Akdede, B.B., Alptekin, K., 2019. Neurocognitive and linguistic correlates of positive and negative formal thought disorder: a meta-analysis. *Schizophr. Res.* 209, 2–11. https://doi.org/10.1016/j.schres.2019.05.025

Brébion, G., David, A.S., Bressan, R.A., Pilowsky, L.S., 2005. Word frequency effects on free recall and recognition in patients with schizophrenia. *J. Psychiatr. Res.* 39(2), 215–222. https://doi.org/10.1016/j.jpsychires.2004.05.010

Brysbaert, M., Buchmeier, M., Conrad, M., Jacobs, A.M., Bölte, J., Böhl, A. 2011. The word frequency effect: a review of recent developments and implications for the choice of frequency estimates in German. *Exp. Psychol.* 58, 412–424. https://doi.org/10.1027/1618-3169/a000123

Brysbaert, M., Diependaele, K., 2013. Dealing with zero word frequencies: a review of the existing rules of thumb and a suggestion for an evidence-based choice. *Behav. Res. Methods* 45(2), 422–430. https://doi.org/10.3758/s13428-012-0270-5

Brysbaert, M., Mandera, P., Keuleers, E., 2018. The word frequency effect in word processing: an updated review. *Curr. Dir. Psychol. Sci.* 27(1), 45–50. https://doi.org/10.1177/0963721417727521

Buck, B., Penn, D.L., 2015. Lexical characteristics of emotional narratives in schizophrenia. *J. Nerv. Ment. Dis.* 203(9), 702–708. https://doi.org/10.1097/nmd.0000000000000354

Cavelti, M., Kircher, T., Nagels, A., Strik, W., Homan, P., 2018. Is formal thought disorder in schizophrenia related to structural and functional aberrations in the language network? A

systematic review of neuroimaging findings. *Schizophr. Res.* 199, 2–16. https://doi.org/10.1016/j.schres.2018.02.051

Cohen, A.S., St-Hilaire, A., Aakre, J.M., Docherty, N.M., 2009. Understanding anhedonia in schizophrenia through lexical analysis of natural speech. *Cogn. Emot.* 23(3), 569–586. https://doi.org/10.1080/02699930802044651

Condray, R., Siegle, G.J., Keshavan, M.S., Steinhauer, S.R., 2010. Effects of word frequency on semantic memory in schizophrenia: electrophysiological evidence for a deficit in linguistic access. *Int. J. Psychophysiol.* 75(2), 141–156. https://doi.org/10.1016/j.ijpsycho.2009.10.010

Corcoran, C.M., Carrillo, F., Fernández-Slezak, D., Bedi, G., Klim, C., Javitt, D.C., Bearden, C.E., Cecchi, G.A., 2018. Prediction of psychosis across protocols and risk cohorts using automated language analysis. *World Psychiatry* 17(1),67–75. https://doi.org/10.1002/wps.20491

Dash, N.S., Arulmozi, S., 2018a. *History, Features, and Typology of Language Corpora*. Springer, Singapore. https://doi.org/10.1007/978-981-10-7458-5

Dash, N.S., Arulmozi, S., 2018b. Limitations of language corpora, in: Dash, N.S., Arulmozi, S., *History, Features, and Typology of Language Corpora*. Springer, Singapore, pp. 259–272. https://doi.org/10.1007/978-981-10-7458-5_15

de Boer, J.N., Brederoo, S.G., Voppel, A.E., Sommer, I.E.C., 2020a. Anomalies in language as a biomarker for schizophrenia. *Curr. Opin. Psychiatry* 33(3), 212–218. https://doi.org/10.1097/yco.0000000000000595

de Boer, J.N., van Hoogdalem, M., Mandl, R.C.W., Brummelman, J., Voppel, A.E., Begemann, M.J.H., van Dellen, E., Wijnen, F.N.K., Sommer, I.E.C., 2020b. Language in schizophrenia: relation with diagnosis, symptomatology and white matter tracts. *npj Schizophr.* 6, 10. https://doi.org/10.1038/s41537-020-0099-3

Docherty, A.R., Berenbaum, H., Kerns, J.G., 2011. Alogia and formal thought disorder: differential patterns of verbal fluency task performance. *J. Psychiatr. Res.* 45(10), 1352–1357. https://doi.org/10.1016/j.jpsychires.2011.04.004

Doughty, O.J., Done, D.J., 2009. Is semantic memory impaired in schizophrenia? A systematic review and meta-analysis of 91 studies. *Cogn. Neuropsychiatry* 14(6), 473–509. https://doi.org/10.1080/13546800903073291

ELAN (Version 5.8), 2019. Max Planck Institute for Psycholinguistics, The Language Archive, Nijmegen. Retrieved from https://archive.mpi.nl/tla/elan

Erdeljac, V., Sekulić Sović, M., (Eds.), 2019. *Interdisciplinary Linguistic and Psychiatric Research on Language Disorders*. FF Press, Zagreb. https://doi.org/10.17234/9789531758314

Foltz, P.W., Rosenstein, M., Elvevåg, B., 2016. Detecting clinically significant events through automated language analysis: quo imus?. *npj Schizophr.* 2(1), 15054. https://doi.org/10.1038/npjschz.2015.54

Gabrić, P., Nagels, A., Kircher, T., Rosenkranz, A., (2021a, April 17–21). *Psychiatric symptoms are differentially associated with verbal fluency performance in patients with schizophrenia and affective disorders* [Poster presentation]. 2021 Congress of the Schizophrenia International Research Society, Online, USA. https://doi.org/10.5281/zenodo.4675702

Gabrić, P., Nagels, A., Kircher, T., Rosenkranz, A., (2021b). *Within-sample, but not corpus-based word frequency of verbal fluency output is associated with positive symptoms in schizophrenia* [Preprint]. PsyArXiv. https://doi.org/10.31234/osf.io/7tndz

Gabrić, P., Vandek, M., (2021). Semantic fluency reveals reduced functional connectivity between subcategorical co-hyponyms in recent-onset inpatients with first-episode psychosis. *Clin. Linguist. Phon.* [Latest Articles]. https://doi.org/10.1080/02699206.2021.1961019

Galaverna, F.S., Morra, C.A., Bueno, A.M., 2014. Verbal fluency in chronic schizophrenia and severity of psychotic symptoms: consideration of their relationship with errors in the tasks. *Eur. J. Psychiatry* 28(3), 154–164. https://doi.org/10.4321/S0213-61632014000300003

Gupta, T., Hespos, S.J., Horton, W.S., Mittal, V.A., 2018. Automated analysis of written narratives reveals abnormalities in referential cohesion in youth at ultra high risk for psychosis. *Schizophr. Res.* 192, 82–88. https://doi.org/10.1016/j.schres.2017.04.025

Heim, S., Dehmer, M., Berger-Tunkel, M., 2018. Beeinträchtigungen von Sprache und Kommunikation bei Schizophrenie. *Nervenarzt* 90(5), 485–489. https://doi.org/10.1007/s00115-018-0647-5

Heister, J., Würzner, K.-M., Bubenzer, J., Pohl, E., Hanneforth, T., Geyken, A., Kliegl, R., 2011. dlexDB – eine lexikalische Datenbank für die psychologische und linguistische Forschung. *Psychol. Rundsch.* 62, 10–20. https://doi.org/10.1026/0033-3042/a000029

Hinzen, W., Rosselló, J., 2015. The linguistics of schizophrenia: thought disturbance as language pathology across positive symptoms. *Front. Psychol.* 6, 971. https://doi.org/10.3389/fpsyg.2015.00971

Huron, C., Danion, J.M., Giacomoni, F., Grangé, D., Robert, P., Rizzo, L., 1995. Impairment of recognition memory with, but not without, conscious recollection in schizophrenia. *Am. J. Psychiatry* 152(12), 1737–1742. https://doi.org/10.1176/ajp.152.12.1737

Iter, D., Yoon, J., Jurafsky, D., 2018. Automatic detection of incoherent speech for diagnosing schizophrenia, in: *Proceedings of the Fifth Workshop on Computational Linguistics and Clinical Psychology: From Keyboard to Clinic*. Association for Computational Linguistics, New Orleans, pp. 136–146. https://doi.org/10.18653/v1/w18-0615

Juhasz, B.J., Chambers, D., Shesler, L.W., Haber, A., Kurtz, M.M., 2012. Evaluating lexical characteristics of verbal fluency output in schizophrenia. *Psychiatry Res.* 200, 177–183. https://doi.org/10.1016/j.psychres.2012.06.035

Kiang, M., Kutas, M., 2006. Abnormal typicality of responses on a category fluency task in schizotypy. *Psychiatry Res.* 145(2–3), 119–126. https://doi.org/10.1016/j.psychres.2005.12.010

Kircher, T., Krug, A., Markov, V., Whitney, C., Krach, S., Zerres, K., Eggermann, T., Stöcker, T., Shah, N.J., Treutlein, J., Nöthen, M.M., Becker, T., Rietschel, M., 2009. Genetic variation in the schizophrenia-risk gene neuregulin 1 correlates with brain activation and impaired speech production in a verbal fluency task in healthy individuals. *Hum. Brain Mapp.* 30(10), 3406–3416. https://doi.org/10.1002/hbm.20761

Kircher, T., Bröhl, H., Meier, F., Engelen, J., 2018. Formal thought disorders: from phenomenology to neurobiology. *Lancet Psychiatry* 5(6), 515–526. https://doi.org/10.1016/s2215-0366(18)30059-2

Krug, A., Markov, V., Krach, S., Jansen, A., Zerres, K., Eggermann, T., Stöcker, T., Shah, N.J., Nöthen, M.M., Georgi, A., Strohmaier, J., Rietschel, M., Kircher, T., 2010. Genetic variation in G72 correlates with brain activation in the right middle temporal gyrus in a verbal fluency task in healthy individuals. *Hum. Brain Mapp.* 32(1), 118–126. https://doi.org/10.1002/hbm.21005

Krug, A., Nieratschker, V., Markov, V., Krach, S., Jansen, A., Zerres, K., Eggermann, T., Stöcker, T., Shah, N.J., Treutlein, J., Mühleisen, T.W., Kircher, T., 2010. Effect of CACNA1C rs1006737 on neural correlates of verbal fluency in healthy individuals. *NeuroImage* 49(2), 1831–1836. https://doi.org/10.1016/j.neuroimage.2009.09.028

Kuperberg, G.R., 2010. Language in schizophrenia Part 1: an introduction. *Lang. Linguist. Compass* 4(8), 576–589. https://doi.org/10.1111/j.1749-818x.2010.00216.x

Kuperberg, G., Caplan, D., 2003. Language dysfunction in schizophrenia, in: R.B. Schiffer, S.M. Rao, B.S. Fogel (Eds.), *Neuropsychiatry, Second Edition*. Lippincott Williams & Wilkins, Philadelphia [etc.], pp. 444–466. Retrieved from https://datascience.iq.harvard.edu/files/kuperberglab/files/kuperbergcaplan_neuropsych_2003.pdf

Maher, B.A., Manschreck, T.C., Molino, M.A.C., 1983. Redundancy, pause distributions and thought disorder in schizophrenia. *Lang. Speech* 26(2), 191–199. https://doi.org/10.1177/002383098302600207

Marino, C., Bernard, C., Gervain, J., 2020. Word frequency is a cue to lexical category for 8-month-old infants. *Curr. Biol.* 30(8), 1380–1386.e3. https://doi.org/10.1016/j.cub.2020.01.070

Markov, V., Krug, A., Krach, S., Whitney, C., Eggermann, T., Zerres, K., Stöcker, T., Shah, N.J., Nöthen, M.M., Treutlein, J., Rietschel, M., Kircher, T., 2009. Genetic variation in schizophrenia-risk-gene dysbindin 1 modulates brain activation in anterior cingulate cortex and right temporal

gyrus during language production in healthy individuals. *NeuroImage* 47(4), 2016–2022. https://doi.org/10.1016/j.neuroimage.2009.05.067

Mendez, M.F., 2018. Non-neurogenic language disorders: a preliminary classification. *Psychosomatics* 59(1), 28–35. https://doi.org/10.1016/j.psym.2017.08.006

Moore, D.J., Savla, G.N., Woods, S.P., Jeste, D.V., Palmer, B.W., 2006. Verbal fluency impairments among middle-aged and older outpatients with schizophrenia are characterized by deficient switching. *Schizophr. Res.* 87(1–3), 254–260. https://doi.org/10.1016/j.schres.2006.06.005

Morrison, C.M., Ellis, A.W., 1995. Roles of word frequency and age of acquisition in word naming and lexical decision. *J. Exp. Psychol. Learn. Mem. Cogn.* 21(1), 116–133. https://doi.org/10.1037/0278-7393.21.1.116

Mota, N.B., Copelli, M., Ribeiro, S., 2017. Thought disorder measured as random speech structure classifies negative symptoms and schizophrenia diagnosis 6 months in advance. *npj Schizophr.* 3(1), 18. https://doi.org/10.1038/s41537-017-0019-3

Nagels, A., Kirner-Veselinovic, A., Krach, S., Kircher, T., 2011. Neural correlates of S-ketamine induced psychosis during overt continuous verbal fluency. *NeuroImage* 54(2), 1307–1314. https://doi.org/10.1016/j.neuroimage.2010.08.021

Nagels, A., Fährmann, P., Stratmann, M., Ghazi, S., Schales, C., Frauenheim, M., Turner, L., Hornig, T., Katzev, M., Müller-Isberner, R., Grosvald, M., Krug, A., Kircher, T., 2016. Distinct neuropsychological correlates in positive and negative formal thought disorder syndromes: the Thought and Language Disorder Scale in endogenous psychoses. *Neuropsychobiology* 73(3), 139–147. https://doi.org/10.1159/000441657

Pauselli, L., Halpern, B., Cleary, S.D., Ku, B., Covington, M.A., Compton, M.T., 2018. Computational linguistic analysis applied to a semantic fluency task to measure derailment and tangentiality in schizophrenia. *Psychiatry Res.* 263, 74–79. https://doi.org/10.1016/j.psychres.2018.02.037

Paulsen, J.S., Romero, R., Chan, A., Davis, A.V., Heaton, R.K., Jeste, D.V., 1996. Impairment of the semantic network in schizophrenia. *Psychiatry Res.* 63(2–3), 109–121. https://doi.org/10.1016/0165-1781(96)02901-0

Pawełczyk, A., Kotlicka-Antczak, M., Łojek, E., Ruszpel, A., Pawełczyk, T., 2018. Schizophrenia patients have higher-order language and extralinguistic impairments. *Schizophr. Res.* 192, 274–280. https://doi.org/10.1016/j.schres.2017.04.030

Piantadosi, S.T., 2014. Zipf's word frequency law in natural language: a critical review and future directions. *Psychon. Bull. Rev.* 21(5), 1112–1130. https://doi.org/10.3758/s13423-014-0585-6

Piras, F., Piras, F., Banaj, N., Ciullo, V., Vecchio, D., Edden, R.A.E., Spalletta, G., 2019. Cerebellar GABAergic correlates of cognition-mediated verbal fluency in physiology and schizophrenia. *Acta Psychiatr. Scand.* 139(6), 582–594. https://doi.org/10.1111/acps.13027

Pomarol-Clotet, E., Oh, T.M.S.S., Laws, K.R., McKenna, P.J., 2008. Semantic priming in schizophrenia: systematic review and meta-analysis. *Br. J. Psychiatry* 192(2), 92–97. https://doi.org/10.1192/bjp.bp.106.032102

Popescu, C.A., Micluţia, I.V., 2006. Semantic fluency in schizophrenia. *J. Evid.-Based Psychot.* 6(2), 105–118. http://jebp.psychotherapy.ro/vol6no2/semantic-fluency-in-schizophrenia/

Popescu, C.A., Miclutia, I.V., Macrea, R., Craciun, I., Zaharia, A., 2007. Semantic fluency in schizophrenia. *Eur. Psychiatry* 22, S133. https://doi.org/10.1016/j.eurpsy.2007.01.426

Rezaii, N., Walker, E., Wolff, P., 2019. A machine learning approach to predicting psychosis using semantic density and latent content analysis. *npj Schizophr.* 5, 9. https://doi.org/10.1038/s41537-019-0077-9

Robert, P.H., Lafont, V., Medecin, I., Berthet, L., Thauby, S., Baudu, C., Darcourt, G., 1998. Clustering and switching strategies in verbal fluency tasks: comparison between schizophrenics and healthy adults. *J. Int. Neuropsychol. Soc.* 4(6), 539–546. https://doi.org/10.1017/S1355617798466025

Rosenstein, M., Foltz, P.W., DeLisi, L.E., Elvevåg, B., 2015. Language as a biomarker in those at high-risk for psychosis. *Schizophr. Res.* 165(2–3), 249–250. https://doi.org/10.1016/j.schres.2015.04.023

Rossell, S.L., David, A.S., 2006. Are semantic deficits in schizophrenia due to problems with access or storage?. *Schizophr. Res.* 82(2–3), 121–134. https://doi.org/10.1016/j.schres.2005.11.001

Rossell, S.L., Batty, R.A., 2008. Elucidating semantic disorganisation from a word comprehension task: do patients with schizophrenia and bipolar disorder show differential processing of nouns, verbs and adjectives?. *Schizophr. Res.* 102(1–3), 63–68. https://doi.org/10.1016/j.schres.2008.04.008

Sabb, F.W., van Erp, T.G.M., Hardt, M.E., Dapretto, M., Caplan, R., Cannon, T.D., Bearden, C.E., 2010. Language network dysfunction as a predictor of outcome in youth at clinical high risk for psychosis. *Schizophr. Res.* 116(2–3), 173–183. https://doi.org/10.1016/j.schres.2009.09.042

Sekulić Sović, M., Erdeljac, V., Kužina, I., 2019. Do shared semantic features facilitate lexical-semantic processing in early course psychosis?. *Clin. Linguist. Phon.* 34(4), 357–365. https://doi.org/10.1080/02699206.2019.1650831

Sumiyoshi, C., Sumiyoshi, T., Nohara, S., Yamashita, I., Matsui, M., Kurachi, M., Niwa, S., 2005. Disorganization of semantic memory underlies alogia in schizophrenia: an analysis of verbal fluency performance in Japanese subjects. *Schizophr. Res.* 74(1), 91–100. https://doi.org/10.1016/j.schres.2004.05.011

Sumiyoshi, C., Ertugrul, A., Yagcioglu, A.E.A., Sumiyoshi, T., 2009. Semantic memory deficits based on category fluency performance in schizophrenia: similar impairment patterns of semantic organization across Turkish and Japanese patients. *Psychiatry Res.* 167(1–2), 47–57. https://doi.org/10.1016/j.psychres.2007.12.009

Sung, K., Gordon, B., Vannorsdall, T.D., Ledoux, K., Pickett, E.J., Pearlson, G.D., Schretlen, D.J., 2012. Semantic clustering of category fluency in schizophrenia examined with singular value

decomposition. *J. Int. Neuropsychol. Soc.* 18, 565–575. https://doi.org/10.1017/S1355617712000136

Tan, E.J., Yelland, G.W., Rossell, S.L., 2016. Characterising receptive language processing in schizophrenia using word and sentence tasks. *Cogn. Neuropsychiatry* 21(1), 14–31. https://doi.org/10.1080/13546805.2015.1121866

Tan, E.J., Wagner, G.A., Rossell, S.L., 2016. Examining lexical processing with two word tasks using the schizotypy analogue. *Psychiatry Res.* 246, 293–295. https://doi.org/10.1016/j.psychres.2016.09.048

Tan, E.J., Neill, E., Tomlinson, K., Rossell, S.L., 2020. Semantic memory impairment across the schizophrenia continuum: a meta-analysis of category fluency performance. *Schizophr. Bull. Open* 1(1), sgaa054. https://doi.org/10.1093/schizbullopen/sgaa054

Tan, E.J., Neill, E., Tomlinson, K., Rossell, S.L., 2021. Corrigendum to: Semantic memory impairment across the schizophrenia continuum: a meta-analysis of category fluency performance. *Schizophr. Bull. Open* 2(1), sgab018. https://doi.org/10.1093/schizbullopen/sgab018

Veleva, I.I., Stoimenova, M.J., Valkova, M.P., 2019. A comparative study of verbal fluency in patients with paranoid schizophrenia, first grade relatives and healthy controls. *Arch. Balk. Medical Union* 54(2), 325–329. https://doi.org/10.31688/ABMU.2019.54.2.16

Weigand, E., 2011. Possibilities and limitations of corpus linguistics, in: Aijmer, K. (Ed.), *Dialogue Analysis VIII: Understanding and Misunderstanding in Dialogue*. Max Niemeyer Verlag, Berlin/New York, pp. 301–318. https://doi.org/10.1515/9783110933239.301

WHO (World Health Organization), 1993. *The ICD-10 Classification of Mental and Behavioural Disorders: Clinical Descriptions and Diagnostic Guidelines*. World Health Organization, Geneva. Retrieved from https://www.who.int/classifications/icd/en/bluebook.pdf

Wittenburg, P., Brugman, H., Russel, A., Klassmann, A., Sloetjes, H., 2006. ELAN: a professional framework for multimodality research, in: Calzolari, N., Choukri, K., Gangemi, A., Maegaard, B., Mariani, J., Odijk, J., Tapias, D. (Eds.), *Proceedings of the Fifth International Conference on Language Resources and Evaluation (LREC'06)*. European Language Resources Association

(ELRA), Genoa, pp. 1556–1559. Retrieved from http://www.lrec-conf.org/proceedings/lrec2006/pdf/153_pdf.pdf