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

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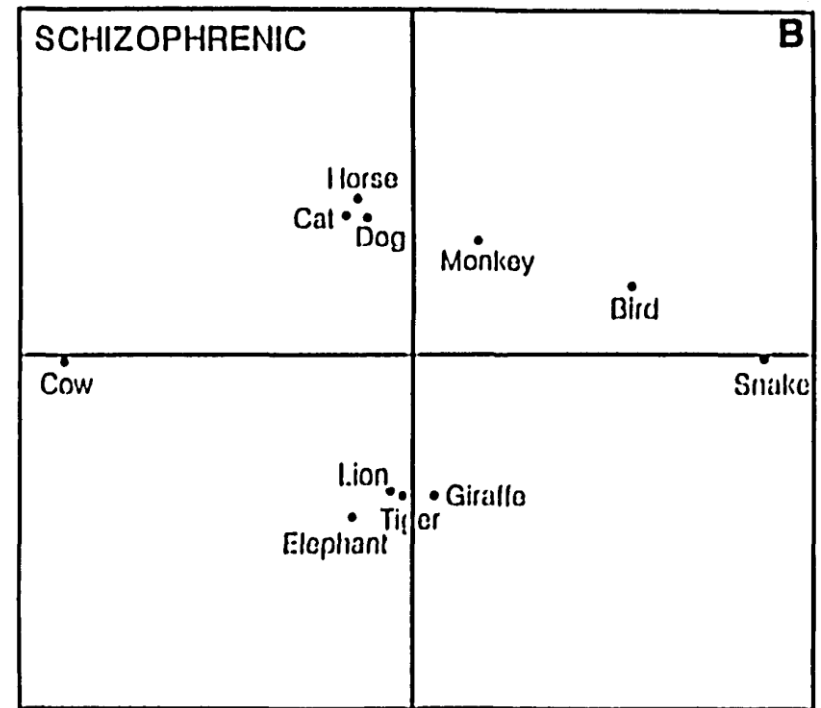
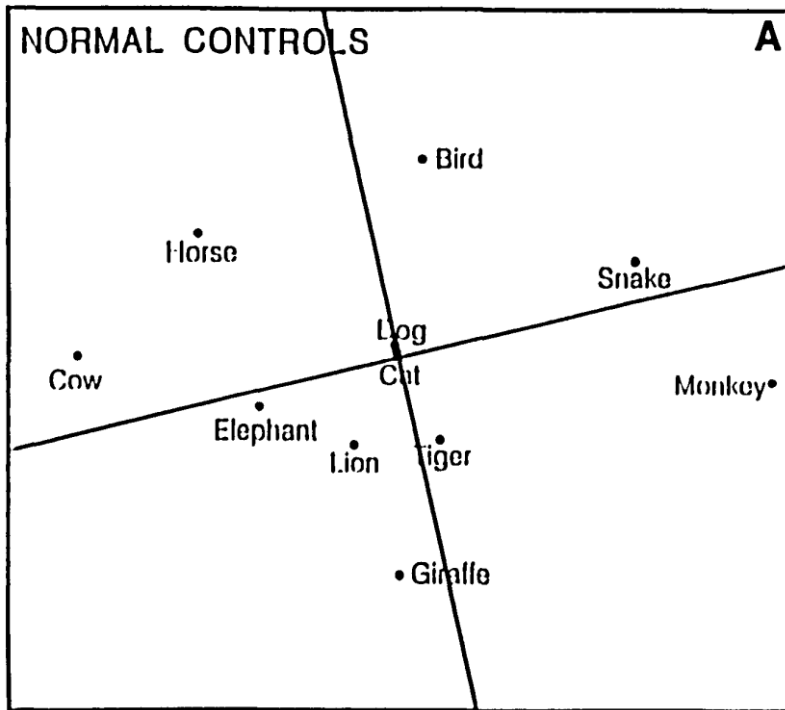
# BACKGROUND

## 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	<b><math>r_s = -.348</math></b> <b><math>p = .038^*</math></b>	$r_s = -.190$ $p = .268$	<b><math>r_s = -.391</math></b> <b><math>p = .018^*</math></b>	<b><math>r_s = -.332</math></b> <b><math>p = .048^*</math></b>	$r_s = -.221$ $p = .194$
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	$r_s = .184$ $p = .284$	$r_s = -.207$ $p = .225$	$r_s = .032$ $p = .854$	<b><math>r_s = .339</math></b> <b><math>p = .043^*</math></b>	$r_s = .215$ $p = .209$

# 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](https://doi.org/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., Gourvitch, 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/npjischz.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.iecii.es/scielo.php?script=sci\\_arttext&pid=S0213-61632016000200001](http://scielo.iecii.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](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/ycp.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/la/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/npjischz.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., Bubbenzer, 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., Rossello, 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>
- Iler, 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](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.ig.harvard.edu/files/kuperberglab/files/kuperbergcaplan\\_neuropsych\\_2003.pdf](https://datascience.ig.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., Kimer-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., Fähmann, 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.schres.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](https://doi.org/10.1016/0165-1781(96)02901-0)
- Pawelczyk, A., Kotlicka-Antczak, M., Lojek, E., Ruszpel, A., Pawelczyk, 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., Miclăuț, I.V., 2006. Semantic fluency in schizophrenia. *J. Evid.-Based Psychot.* 6(2), 105–118. <http://ebp.psychotherapy.ro/vol6no2/semantic-fluency-in-schizophrenia/>
- Popescu, C.A., Miclăuț, 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., Thuaby, 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., Ertegür, 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.pschres.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.pschres.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>
- Wingard, 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](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/npjrschz.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](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](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/ycp.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/npjrschz.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., Bubbenzer, 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>
- Juhász, 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](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](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.psych.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](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., Micluția, 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., Thaubly, 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](http://www.lrec-conf.org/proceedings/lrec2006/pdf/153_pdf.pdf)