Network Analysis of Language Disorganization in Patients with Schizophrenia

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Language disorganization, an objective component of formal thought process abnormality, has been regarded as a core symptom of schizophrenia from an evolutionary psychopathology perspective. However, to the best of our knowledge, the network structure of language disorganization has rarely been examined in patients with schizophrenia. Thus, our preliminary study aimed to evaluate the network structure using the Clinical Language Disorder Rating Scale (CLANG) in 167 inpatients with schizophrenia. All 17 of the CLANG items were considered to be ordered categorical variables ranging from 0 to 3. Our results indicated that disclosure failure, excess syntactic constraints, abnormal prosody, and aprosodic speech rank among the top five central domains within the network structure. We deemed that disclosure failure and prosody problems are the most important symptoms of language disorder in schizophrenia. Thus, reduced top-down processing of linguistic information may be a core neurobiological underpinning of language disorganization in schizophrenia. Further studies controlling for the potential effects of confounding factors (i.e., duration of illness) on network analyses of language disorder and formal thought disorder are warranted in patients with schizophrenia.

Key Words: Language disorganization, disclosure failure, network structure, schizophrenia
tion of symptoms, central symptoms can be characterized by
greater influences on the network structure rather than periph-
eral symptoms.6 To the best of our knowledge, the network struc-
tures of positive and negative symptoms, but not language,
have been estimated in patients with schizophrenia. Thus, our
preliminary study aimed to estimate the network structure of
language disorganization in patients with schizophrenia.

As described elsewhere,7 during a survey period from Janu-
ary to June 2014, a total of 167 inpatients with DSM-5 diagnosed
schizophrenia8 were recruited from Yong-In Mental Hospital
and Chuncheon National Hospital in Korea. Inclusion criteria
were age between 19 and 64 years, having greater than 2 weeks
of psychiatric hospitalization, and attainment of over 6 years of
education. Exclusion criteria were comorbid organic mental
disorders, intellectual disability, alcohol or substance abuse,
seizure disorders, neurological disorders, and severe physical
disorders. DSM-5 was used in the evaluation of psychiatric dis-
orders. Principally, the Thurstone Word Fluency Test was used
to detect intellectual disability, given that it has been shown to
be positively correlated with intelligence quotient and letter as-
sociation condition.9 The study protocol and case report form
were approved by the Institutional Review Board of Yong-In
Mental Hospital (receipt number: 2013-49). Language disor-
ganization in the study participants was evaluated with the
Clinical Language Disorder Rating Scale (CLANG),10 which as-
sessed language disorganization and observable expressions
of formal thought disorder. CLANG includes a total of 17 items,
which are rated on a Likert scale from 0 (normal) to 3 (severe)
and has been translated and formally standardized in Korean.7

Using the R-package qgraph,11 the network structure of the
17 CLANG items was estimated in the study participants. The
nodes (symptoms) and edges (associations among the symp-
toms) both constituted the network structure. In addition, the
false positive edges were controlled with the least absolute
shrinkage and selection operator (LASSO);12 therefore, very
small edges were set exactly to zero. Moreover, using the GLAS-
SO (or graphical LASSO) procedures,13 the average edge was
defined with the relationship level between two symptoms con-
trolling for all other relationships within the network. Us-
ing the shrinkage parameter, extended Bayesian information
criteria were minimized, and the underlying network structure
was accurately recovered.14,15 All CLANG items were regarded
as ordered-categorical variables and ranged from 0 to 3. Using
the modularity-based community-detection algorithm, node
clusters were investigated. Using the spin-glass algorithm, we
tested whether the number and weighted strength of edges
within a cluster exceeded those within another cluster, in terms
of communities within the network.16,17 In terms of centrality
indices, node strength centrality was defined as the sum of all
associations of a given node with all other nodes, and closeness
centrality was defined as a measure of how close a symptom
was to all other symptoms. Finally, betweenness centrality was
defined as the shortest length of a path connecting any two
nodes. Thus, since node strength centrality was substantially
correlated with closeness centrality and betweenness central-
ity, the most central symptoms were estimated within the net-
work structures of the 17 CLANG items.

As described elsewhere,7 the mean age and mean duration

<table>
<thead>
<tr>
<th>Table 1. Percent Scores for the CLANG Items (n=167)</th>
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<tbody>
<tr>
<td><strong>CLANG items</strong></td>
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<tr>
<td>1. Excess phonetic association</td>
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<td>2. Abnormal syntax</td>
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<tr>
<td>3. Excess syntactic constrains</td>
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<td>4. Lack of semantic association</td>
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<td>5. Referential failures</td>
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<td>6. Disclosure failure</td>
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<td>7. Excess details</td>
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<td>8. Lack of details</td>
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<td>9. Aprosodic speech</td>
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<tr>
<td>10. Abnormal prosody</td>
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<td>11. Pragmatics disorder</td>
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<td>12. Dysfluency</td>
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<td>13. Dysarthria</td>
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<td>14. Poverty of speech</td>
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<td>15. Pressure of speech</td>
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<td>16. Neologisms</td>
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<td>17. Paraphasic error</td>
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ABP, abnormal prosody; APR, aprosodic speech; ART, dysarthria; ASS, lack of semantic association; ASY, abnormal syntax; CLANG, Clinical Language Disorder Rating Scale; DSC, disclosure failure; EDE, excess details; ESY, excess syntactic constrains; FLU, dysfluency; LDE, lack of detail; NEL, neologisms; PAR, paraphasic error; PHO, excess phonetic association; POV, poverty of speech; PRA, pragmatics disorder; PRS, pressure of speech; REF, referential failure.
of illness of the study participants were 46.5 (SD=11.2) years and 20.9 (SD=10.3) years, respectively (Supplementary Table 1, only online). More than half of the participants were men (51.5%), unmarried (79.1%), educated below a high school graduate level (73.0%), religiously-affiliated, and recruited from Yong-In Mental Hospital (86.8%). In addition, the mean chlorpromazine equivalent dose of prescribed antipsychotics was 921.1 (SD=952.0) mg per day. The abbreviations and percentages of the CLANG items are presented in Table 1.

Fig. 1A shows how a psychopathological network consisting of the CLANG items was constructed. In terms of the edge statistics, about 88% (n=120) of all possible 136 edges were estimated to be above zero. The estimated network revealed strong positive connections between pragmatic disorder and paraphasic error (0.806), aprosodic speech and abnormal prosody (0.679), lack of detail and poverty of speech (0.611), excess syntactic constraints and referential failures (0.598), excess phonetic association and neologisms (0.528), excess syntactic constraints and abnormal prosody (0.506), and referential failures and aprosodic speech (0.506). On the contrary, the network revealed strong negative connections between poverty of speech and pressure of speech (-0.552), poverty of speech and neologisms (-0.521), and referential failures and abnormal prosody (-0.514). Remarkably, pragmatics disorder, excess phonetic association, and dysfluency were largely isolated within the network. A community-detection method revealed an organization of roughly five clusters as follows: Cluster A included excess phonetic association, pragmatics disorder, neologisms, and paraphasic error. Cluster B included abnormal syntax, lack of semantic association, disclosure failure, excess details, and
pressure of speech. Cluster C included excess syntactic constraints and referential failures. Cluster D included lack of details and poverty of speech. Finally, cluster E included aprosodic speech, abnormal prosody, dysfluency, and pressure of speech.

In terms of the node statistics, there were no abrupt changes with smooth declines in symptom importance as shown in Fig. 1B. Disclosure failure was most centrally situated within the network, followed by excess syntactic constraints and abnormal prosody; therefore, it also showed the highest symptom importance within the network. On the contrary, as pragmatic disorder was nearly unconnected, it represented the lowest node strength within the network, followed by excess phonetic association, and dysfluency.

In our findings, variability in node strength centrality for the 17 CLANG items was estimated. Disclosure failure, excess syntactic constraints, abnormal prosody, and aprosodic speech (mainly related to the disturbance of disclosure and prosody) ranked among the top five central symptoms (ranking 1, 2, 4, and 5 out of 17, respectively) within the network. In contrast, pragmatic disorder, excess phonetic association, and abnormal syntax (mainly related to the disturbance of association) were among the five most peripheral symptoms (ranking 17, 16, and 14 out of 17, respectively). Thus, as disclosure failure and dysprosody were situated relatively centrally and associative disturbance was situated relatively peripherally within the network, we speculated that self-monitoring problems may be the most influential constituent of language disorganization in schizophrenia. Most notably, disclosure failure was the most central domain within the estimated network of language disorganization in patients with schizophrenia. According to definitions in CLANG, disclosure failure (loss of schematic disorganization) involves a “lack of normal organization in which larger speech units progress from one context to the next in a gradual and prepared manner.” The immediate failure to construct coherence links contributes to building meaning across the sentences (discourse) in patients with schizophrenia. Also, schizophrenia patients, rather than normal controls, have been characterized by less connection between ideas and clauses. Language disorder of schizophrenia can be closely related to a reduction in the top-down process of linguistic information. Herein, our findings suggest that disclosure failure may be a relatively essential factor of language disorganization from a psychopathological network perspective. Furthermore, one study has shown that dysprosody is lateralized to nondominant hemispheres in epilepsy patients. Thus, we suspect that language disorganization may be neurobiologically underpinned by dysfunction of the nondominant hemisphere. Remarkably, the five organized clusters of language disorganization are partly consistent with the five-factor solution, including pragmatics (i.e., paraphasic error, pragmatics disorder), disclosure (i.e., lack of semantic association, abnormal syntax, disclosure failure, lack of details, dysarthria), production (i.e., excessive de-

ACKNOWLEDGEMENTS

This work was supported by the 2019 an Inje University Research Grant. We would like to thank Dr. Jinseob Kim for his valuable help with the network analysis.

AUTHOR CONTRIBUTIONS

**Network of Language Disorganization**

**References**


