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INVESTIGATION AND COMPARISON OF NETWORKS OF PSYCHOPATHIC TRAITS IN PSYCHIATRIC INPATIENTS AND UNIVERSITY STUDENTS

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SUMMARY

The Levenson Self-Report Psychopathy Scale (LSRPS) is a psychometric tool composed of 26 items to assess psychopathic traits. This study aims to perform a network analysis of this scale in a large sample composed of 100 hospitalized psychiatric patients and 256 French-speaking Belgian university students in medicine and to compare the network structure.

We estimated a regularized partial correlation network for the 26 items of the questionnaire. Node predictability is used to assess the connectivity of items. The network comparison test (NCT) and statistical inference on sum scores are conducted to compare networks from the inpatients and the university students.

The networks composed of LSRPS are mostly connected positively, but some negative interconnections were observed in both inpatients and university students, and node connectivity varies. Although the scores from inpatients are substantially higher than those of university students, network analysis didn't show any statistical difference in the overall connectedness.

Network analysis is a valuable tool for exploring psychopathic traits and offers new insight into how they interact. In the network estimation, we concluded that the two domains of psychopathy are interrelated. This interconnectivity was observed in both subject groups. We hypothesize that such interconnectivity was present because environmental and genetic factors are intricately intertwined in the appearance of primary and secondary psychopathy. Meanwhile, although inpatients may have higher scores of psychopathic traits, those traits' connectedness isn't different from that of the general population. This finding aligns well with the theory of hysteresis in network analysis, which states that the connections among components of mental disorders do not disappear or reappear over time, but their importance may vary. Further studies may replicate our findings using different sample groups.

Key words: *psychopathy - network analysis - partial correlation*

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INTRODUCTION

Psychopathy is the commonly used name for antisocial personality disorder (ASPD), as a pattern of socially irresponsible, exploitative, and guiltless behavior that begins in childhood or early adolescence and manifests in disturbances in many areas of life. Typical behaviors include criminality and breaking the law, failure to maintain steady employment, manipulation of others for personal gain, and failure to develop stable interpersonal relationships. Other characteristics of ASPD include a lack of empathy for others, rarely feeling remorse, and failing to learn from the negative results of one's experiences (Coutanceau 2013).

ASPD is a common disorder in psychiatry. The overall prevalence in the general population is around 3% in men and 1% in women (Coutanceau 2013) (American Psychiatric Association 2015), and the prevalence in populations of patients with severe psychiatric disorders varies from 0% to 13% (Côté et al. 2000). Several methods give the diagnosis of ASPD. In this study, psychopathy traits were measured using the Levenson Self-Report Psychopathy Scale (LSRPS) (Levenson et al. 1995). The LSPRS is widely used to measure traits of psychopathy. It was developed to reflect the dual-factor model of psychopathy (Hare et al. 1990, Antaramian et al. 2010). with items reflecting both primary psychopathy, characterized by emotional deficits and selfish and manipulative behavior, and items reflecting secondary psychopathy, antisocial behavior, and reflecting impulsivity. In fact, secondary psychopathy potentially increases a person's vulnerability to chronic misbehavior (Newman et al. 2005). Therefore, the distinction between the two types of psychopathy is essential to diagnose a patient.

Several studies have used the LSPRS to assess antisocial personality disorder (Sellbom 2011): as many other psychometric tools in various psychiatric constructs, the LSPRS conceives the disorder as a common cause; however, symptoms or traits are likely to influence each other, and it is unfeasible to analyze such "complexity" with classic statistical methods (Marsman et al. 2018). It is different from most somatic diseases, which cause the symptoms, interchangeable consequences of their common cause.

In recent years, a new way of analyzing psychiatric constructs as complex systems have been proposed called the network approach (Borsboom 2017). Such complex systems have been investigated in empirical studies using network models, which depict a given construct emerging from mutual interactions of its elements, such as symptoms or personality traits (Borsboom & Cramer 2013). The ongoing feedback loops that go from one symptom to another and mutually reinforce both can worsen a patient's mental state until it can be defined as a mental disorder. The "network" theory of mental disorders (Borsboom 2017) has been applied in different fields of psychopathology, such as alexithymia (Briganti 2019), autism (Deserno et al. 2017), depression (Briganti et al. 2020), empathy (Briganti et al. 2018), narcissistic personality (Briganti & Linkowski 2019).

This study aims to investigate the complexity of psychopathic traits using the LSPRS in two different populations. The first is a sample of patients hospitalized with severe presentation of different mental illnesses such as psychotic disorders, bipolar disorders, mood disorders, and personality disorders. The other one is a sample of medical students in a French-speaking Belgian university in medicine, which we can approximate to be a sample from the general population. Investigating the connectivity of psychopathic traits in both populations and investigating the difference between the two can help gather information about the psychopathological processes surrounding antisocial behavior in the general population and inpatients.

The study is structured as follows. First, we present the methods and samples used to investigate psychopathic traits, Second, we present the results from our different analyses. Third, we discuss our results and highlight the potential limitations of our study.

METHODS

Data

Measurement

We used the LSPRS, a psychometric scale composed of 26 items graded on a four-point Likert scale (Strongly Disagree to Strongly Agree). It was developed to reflect the dual-factor model of psychopathy (Hare et al. 1990), with 16 items revealing primary psychopathy characterized by emotional deficits and selfish and manipulative behavior, and the other 10 items measuring secondary psychopathy, antisocial behavior and reflecting impulsivity. English and French questionnaires were made available for subjects depending on their mother tongue.

Items such as 5, 11, 14, 17, 19, 23, and 24 were made to assess the subject's planning skills and compassion. Subjects who chose "strongly disagree" are deemed to have psychopathic traits thus, reversed numerical values were used for the data analysis.

Data set 1: inpatients

The first data set is composed of 100 hospitalized patients in secure psychiatric units of CHU Brugmann, due to severe mental illnesses, such as psychotic disorders (including schizophrenia) (59%), mood disorders (depression and bipolar) (32%), and personality disorders (9%). The survey was conducted from administering the scale during direct interviews with the patients. Patients had a relatively stable mental state when examined (i.e., where compliant with the interview and not aggressive). All subject responses become anonymous once encoded in the initial data set to preserve patient confidentiality. The selection criteria for patients in this prospective study database are as follows: patients aged between 18 and 79, hospitalized in one of two secure psychiatric inpatients units of CHU Brugmann. The interviews were conducted from 10th June 2021 to 22nd February 2022.

Data set 2: university students

The second data set is composed of 254 medical students from the school of medicine of the Université libre de Bruxelles, a French-speaking Belgian university. The survey was carried out with Microsoft Forms. The survey was conducted from 4th to 15th March 2022.

Network analysis

Software

We use R (version 4.1.1, available at https://www.r-project.org) for statistical computing. The packages bootnet (Epskamp, Borsboom, et al. 2018), qgraph (Epskamp et al. 2012), NetworkComparisonTest (van Borkulo et al. 2016) and igraph (Csardi & Nepusz 2006) are used for network estimation and inference.

Network estimation

Network are graphs composed of nodes (in this case, items from the scale) and edges (connections among nodes). The relative importance of an edge is denoted through thickness and color saturation. In the case of psychopathological networks, edges are unobserved and must be estimated. We use a family of network models, specifically, the pairwise Markov Random Fields (PMRFs) that depict mutual interactions among items (Shah et al. 2021). To estimate a PRMF when using ordinal scale items, the best approximation strategy is to use a Gaussian Graphical Model, a partial correlation network (Epskamp et al. 2018, p. 2018). Partial correlations can be considered as a statistical counterpart of conditional probabilities and are estimated by inverting the data's variance-covariance matrix. To avoid the presence of spurious partial correlation in the model, an l1-regularization method, namely, the Graphical Least Absolute Shrinkage and Selection Procedure (GLASSO) procedure (Friedman et al. 2014) is used to obtain a final, regularized partial correlation network. Nodes are placed in the network using the Fruchterman-Reingold algorithm: closely connected nodes will be next to each other (Fruchterman & Reingold 1991). Blue edges represent positive regularized partial correlations, while red edges represent negative regularized partial correlations. Thickness and couleur intensity of an edge show its weight.

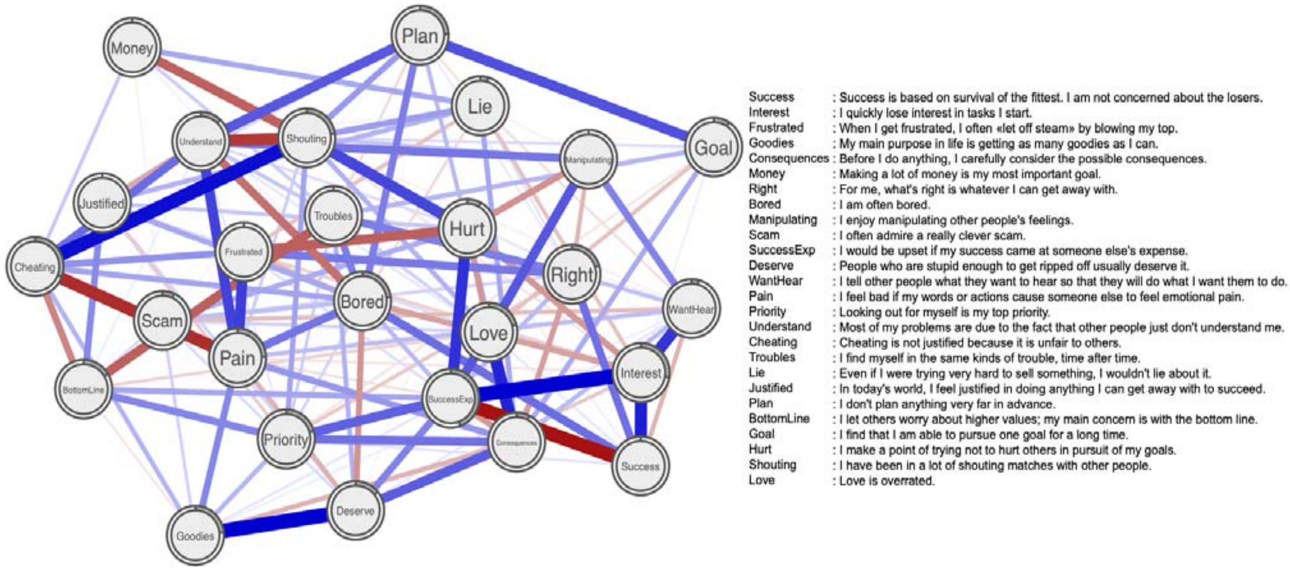

Figure 1. Composed network

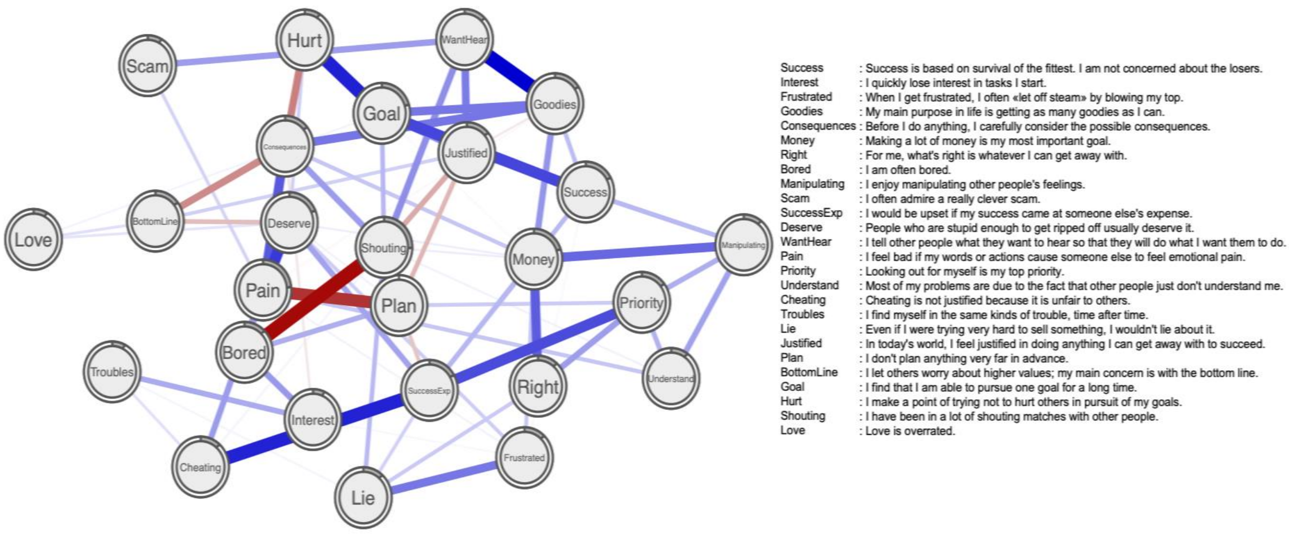

Figure 2. Estimated network

Network inference

Centrality

Centrality measures are used to detect which nodes are more interconnected than others in the network and can, therefore, better predict/be predicted by other nodes in the network (Boccaletti et al. 2006). Strength, the absolute sum of regularized partial correlations, is the specific centrality measure used in this work.

Node predictability

An additional measure of node connectivity, node predictability, is used: predictability is the R^2 estimate for each node in the network based on other nodes. It reflects what percentage of a node's variability can be explained by other nodes. Node predictability is visualized as a pie chart surrounding the node: the fuller the pie chart, the higher the node predictability (Opsahl et al. 2010).

Network accuracy and stability

State-of-the-art accuracy and stability tests are carried out through the resampling procedure of bootstrapping, that is, re-estimating the network structure a number of times: in our case, 2000 bootstraps were used (Epskamp et al. 2018).

Network comparison test and statistical inference on sum scores

To compare network structures, we use the NCT, which assesses differences in the global connectivity of the network structures (van Borkulo et al. 2016). We also performed a Mann-Whitney U test to infer whether the scores of inpatients were statistically higher than the scores of students, indicating that the presence of a severe mental disorder may be associated with higher psychopathic traits than in the healthy population.

RESULTS

Data set 1: Inpatients

Descriptive statistics

The overall score of the 26 itemed LSPRS averaged 52.4 out of 104. Inpatients were 53% female and 47% male, with an average age of 42.4 years and a standard deviation of 14.6 years. The detail of the distribution of item scores in university students is reported in the supplementary materials.

Network estimation

Figure 1 illustrates the network composed of the 26 items of LSPRS. Overall, the network shows mainly positive connections, but some negative connections were also observed. Item 4 ("My main purpose in life is getting as many goodies as I can") and item 12 ("People who are stupid enough to get ripped off usually deserve it") are strongly associated. These two belong to the same domain of egocentricity in primary psychopathy.

Several connections were found between items belonging to different domains. For instance, item 17 ("Cheating is not justified because it is unfair to others") from primary psychopathy is connected to item 25 ("I have been in a lot of shouting matches with other people") from secondary psychopathy. Item 2 ("I quickly lose interest in tasks I start") from secondary psychopathy and item 11 ("I would be upset if my success came at someone else's expense") from primary psychopathy. Item 1 ("Success is based on survival of the fittest; I am not concerned about the losers") from primary psychopathy is connected to item 2 ("I quickly lose interest in tasks I start") from secondary psychopathy. The connection between item 1 ("Success is based on survival of the fittest; I am not concerned about the losers") and item 11 ("I would be upset if my success came at someone else's expense") was negative in the network.

Network inference

Centrality

Item 11 ("I would be upset if my success came at someone else's expense") presents the highest strength estimate (= 3.31), which means that it is the most interconnected node in the network. Item 8 ("I am often bored") and item 25 ("I have been in a lot of shouting matches with other people.") (= 3.07 and = 3.03, respectively) also show high centrality.

Node predictability

Mean node predictability was 15.3%, which means that on average 15.3% of a node's variance is explained by its neighboring nodes. Item 11 ("I would be upset if my success came at someone else's expense") had the highest node predictability estimate followed by 31.8% on item 17 ("Cheating is not justified because it is unfair to others") and 31.2% on item 5 ("Before I do anything, I carefully consider the possible consequences"). Three items showed a 0% predictability: item 3 ("When I get frustrated, I often «let off steam» by blowing my top"), item 6 ("Making a lot of money is my most important goal"), item 16 ("Cheating is not justified because it is unfair to others") and item 20 ("In today's world, I feel justified in doing anything I can get away with to succeed").

Network accuracy and stability in inpatients

The centrality stability coefficient was 0.28, meaning we can drop 28% of the sample and still obtain 75% of correlation between centrality order. Based on the edge weight difference test, some edges were found to be significantly more potent than the others, however, the centrality difference test showed that we could not conclude any statistical difference between any nodes.

Data set 2: University students

Descriptive statistics

The overall score of the 26 itemed LSPRS averaged 48.4 out of 104. Students were 72.4% female and 27.6% male, with an average age of 24.5 years and a standard deviation of 4.0 years. The detail of the distribution of item scores in university students is reported in the supplementary materials.

Network estimation

Figure 2 illustrates the estimated network of the 26 items of LSPRS. Overall, the network shows mainly positive connections, but some negative connections are also observed.

Item 1 ("Success is based on survival of the fittest; I am not concerned about the losers") and 13 ("I tell other people what they want to hear so that they will do what I want them to do") are strongly associated: both are from primary psychopathy. Item 12 ("People who are stupid enough to get ripped off usually deserve it") and item 14 ("I feel bad if my words or actions cause someone else to feel emotional pain") are also related and both from primary psychopathy.

Several connections are also found between items connecting different domains. For instance, item 23 ("I find that I am able to pursue one goal for a long time") from the secondary psychopathy and item 24 ("I make a point of trying not to hurt others in pursuit of my goals") from the primary psychopathy, item 2 ("I quickly lose interest in tasks I start") from the secondary psychopathy and item 17 ("Cheating is not justified because it is unfair to others") from the primary psychopathy. Item 2 is also strongly connected to item 11 ("I would be upset if my success came at someone else's expense") the primary psychopathy.

Some negative edges are also found in the network. Item 14 ("I feel bad if my words or actions cause someone else to feel emotional pain") from the primary psychopathy and item 21 ("I don't plan anything very far in advance") from the secondary psychopathy were characterized as negative edge in the network. Item 8 ("I am often bored") and item 25 ("I have been in a lot of shouting matches with other people") were also highly negatively connected despite both being from secondary psychopathy.

Network inference

Centrality

shows strength centrality estimates for the 26-item LSPRS of university students. Item 25 ("I have been in a lot of shouting matches with other people") presents the highest strength estimate (= 2.10), which means that it is the most interconnected node in the network.

Item 14 ("I feel bad if my words or actions cause someone else to feel emotional pain", = 1.99,) item 6 ("Making a lot of money is my most important goal", = 1.95), item 21 ("I don't plan anything very far in advance", = 1.95) and item 5 ("Before I do anything, I carefully consider the possible consequences", = 1.91) show also strong centrality.

Node predictability

Mean node predictability was 13.2%. The highest score is 24.9% of predictability on item 25 (Shouting), 22.8% on item 14 (Pain), 21.0% on item 6 (Money) and 20.4% on item 23 (Goal). On the other hand, item 10 (Scam) and item 26 (Love) predictability is all 0%.

Network accuracy and stability in students

The centrality stability coefficient was 0.44, meaning we can drop 56% of the sample and still obtain 75% of correlation between centrality order. Based on the edge weight difference test, some edges were significantly more substantial than the others, however, the centrality difference test showed that we could not conclude any statistical difference between any nodes.

Comparison between the inpatients and the university students

The network invariance test resulted in a p-value of 1. The networks estimated from both the inpatients and the University students were substantially similar and didn't show any statistical difference in the overall connectedness.

The unilateral Mann-Whitney U test for sum score comparison reported $p<0.001$, indicating that the scores from inpatients were substantially higher than those of university students, with a rank-biserial correlation effect size of 0.210 (slight overall difference).

DISCUSSION

To our knowledge, this is the first application of network analysis using the LSPRS in psychopathy research. This study highlights the connections among psychopathic traits and provides new insights into how they interact. Two groups of subjects were analyzed using LSPRS; one group consisted of psychiatric inpatients, and the other consisted of university students.

In the network estimation, several strong edges were observed within each group. The analysis also showed a significant number of connections between primary and secondary psychopathy. We noted that the two domains of psychopathy were interrelated. This interconnectivity was observed in both subject groups. We hypothesize that such interconnectivity was present because environmental and genetic factors are intricately intertwined in the appearance of primary and secondary psychopathy (Newman et al. 2005).

Items representing secondary psychopathy (items 25, 21, and 5) showed high centrality (and predictability) among university students. Since these items are meant to evaluate the capacity to control impulse and emotion, the elevated interconnectedness of such items may be explained by the fact that the well-described traits of "self-control," "academic striving," and "conscientious student diligence" ultimately contribute to a student's academic success (Sobowale et al. 2017), and these directly relate to impulse and emotion control. While analyzing inpatients, higher centrality (and predictability) was observed on items measuring callousness (item 11, 17, 24, 14) of the primary psychopathy. However, we couldn't find any empirical studies which could explain this phenomenon: future experiments and cross-sectional research may endeavor to explore the role of callousness as a psychopathic trait in psychiatric inpatients with severe forms of mental disorders.

No statistical difference was found between the two groups. In contrast, the scores obtained from inpatients were substantially higher than those of university students. Therefore, although inpatients may have higher scores of psychopathic traits, the connectedness of those traits is not different from that of the general population. This finding aligns well with the theory of hysteresis in network analysis, which states that the connections among components of mental disorders don't disappear or reappear over time, but their importance may vary (Cramer et al. 2016).

Our findings should be interpreted in the light of several limitations. Firstly, the number of interviewed inpatients was limited with a stability coefficient of 0.28. Thus, further studies including a larger sample protocol will enhance our results. Secondly, the university students may not be representative of the general population. The average age of this group was only 24.8 years, and 72.1% were women. Thirdly, ASPD should be diagnosed after stabilizing for other mental disorders (First 2016): this study limits its analysis to identifying how psychopathic traits present in severe but stabilized inpatients under appropriate treatments. Lastly, some negative connections were observed in the networks. Therefore, further investigations are required using Bayesian network analysis to identify whether the negative connections are the result of a collider structure: two items causing a third items, with a negative connection appearing among the two causing items. (Marsman et al. 2018)

Future studies may endeavor to replicate our findings in other samples and extending the investigation and comparison of network structures of psychopathic traits to broader samples of psychiatric patients as well as other samples from the general populations.

CONCLUSION

Network analysis is a valuable framework for exploring psychopathic traits and offers new insight into how they interact. In the present studies, we were able to investigate the connectedness of psychopathic traits, highlight the nature of such interactions in different samples, and infer the relative and absolute importance of domains of psychopathic traits.

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Contribution of individual authors:

Takuyoshi Sunakawa collected and analyzed the data and wrote the first draft of the manuscript;

Giovanni Briganti designed the original study, supervised the data analysis and reviewed the manuscript.

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