# Cocaine use disorder criteria in a clinical sample: an analysis using Item Response Theory, Factor and Network analysis

Running head: Network analysis of cocaine use disorder criteria

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**Abstract**

**Background**: The conceptualization of substance use disorders (SUDs) was modified in successive editions of the DSM. Dimensionality and inclusion/exclusion of several criteria was studied using various analytic approaches. **Objective**: The study aimed to deepen our knowledge of the interrelationships between the diagnostic criteria for cocaine use disorder (CUD), applying three different analytical techniques: factor analysis, Item Response Theory (IRT) models, and network analysis. **Methods**: 425 (85.4% male) outpatients were evaluated for CUD using the Substance Dependence Severity Scale. Confirmatory Factor Analysis, 2-parameter logistic model (IRT) and network analysis were applied to analyse the relationships between the diagnostic criteria. **Results**: The results show that "legal problems" criterion is not congruent with the CUD measure on three analyses. Also, network analysis suggests the usefulness of the "craving" criterion. The criterion "quit/control" is the one that presents the best centrality indices and expected influence, showing strong relationships with the criteria of "craving", "tolerance", "neglect roles" and "activities given up". **Conclusions**: Network analysis appears to be a useful and complementary technique to factor analysis and IRT for understanding CUD. The "quit/control" criterion emerges as a central criterion to understand CUD.

**Keywords**: Substance Use disorders; Nosology; Network analysis; Factor Analysis; Item Response Theory; Severity of dependence

The conceptualization of substance use disorders (SUDs) was modified in successive editions of the DSM. SUDs firstly appeared as disorders independent from personality disorders in the DSM-III [1]. This edition also introduced the distinction between the categories of "abuse" and "dependence," although it was not until the emergence of the DSM-III-R that the diagnostic criteria were operationalized [2]. This biaxial classification established that if a patient met the diagnostic criteria for dependency, then no abuse was diagnosed. Implicitly, this established a hierarchy between these two diagnostic categories [3].

This way of conceptualising SUD has been maintained in DSM-IV [4] and DSM-IV-TR [5] editions, although it has not been without criticism. Although some studies applying factor analysis found support for the existence of both dimensions [6], the majority of the studies using factor analysis demonstrated that the diagnostic criteria of abuse and dependence correspond to a one-dimensional construct [3, 7,8]. In addition, studies conducted using Item Response Theory (IRT) revealed that the diagnostic criteria of abuse and dependence are closely interlinked along a continuum, and thus their criteria cannot adopt a hierarchical structure [9,10].

A further nosological debate surrounding SUD concerns the elimination of the diagnostic criterion of "legal problems" and the inclusion of the "craving" criterion in the DSM-5. Studies using factor analysis and IRT reported that the "legal problems" criterion did not fit the factor structure [11]. With regard to the inclusion of "craving", some authors have emphasised the clinical utility of this diagnostic criterion [12, 13], although in measurement terms, others claimed that it provides no advantages in terms of accuracy [14]. Thus, it is necessary to further explore the contribution of the "craving" criterion toward the diagnosis of SUD.

This empirical evidence grounded the changes introduced in the DSM-5 [15]. The substance abuse and dependence categories have been replaced by a single dimension known as substance use disorder (SUD). This includes the seven diagnostic criteria of the former category of "dependence" and three diagnostic criteria of the "abuse" category (excluding the "legal problems" criterion). In addition, the "craving" criterion, or a strong desire to use a substance, was included.

As we have seen, the nosological changes introduced derive largely from the application of factor analysis techniques and IRT models. In recent years, the network analysis technique has been applied in the field of mental disorders [16-18]. This technique assumes that disorders can be understood as a cluster of interrelated symptoms or diagnostic criteria which are referred to as nodes. Through the analysis of these relationships, it is possible to identify community structure; that is, groups of nodes that are more densely connected to each other [19]. Additionally, it allows for establishing how each node relates to the rest of the nodes in the network [20], and which criteria or symptoms have a greater influence on the others, in order to address them clinically [21].

Despite its usefulness, the application of network analysis to the study of SUD is still relatively rare. To date, only four studies can be found in which network analysis has been applied to SUD criteria, and all of these were conducted with drug users who responded to population surveys [22-25]. However, no studies have been carried out with patients diagnosed with SUD in treatment, despite the fact that patients in treatment for SUD and drug users have different profiles. On the other hand, no studies have jointly analysed the DSM-IV and DSM-5 criteria using network analysis. To summarize, it can be noted that at present there is still a need for empirical evidence on the utility of craving for the diagnosis of SUD. In addition, to extend our knowledge

regarding the diagnosis of SUD, it will be useful to establish how the diagnostic criteria are interrelated. Therefore, the present study had the following objectives:

i) To replicate the factor and IRT analyses for cocaine use disorder (CUD) following DSM-IV and DSM-5 criteria in a sample of outpatients and tests the usefulness of the diagnostic criteria of "legal problem" and "craving".

ii) To analyse the individual interrelationships between the SUD diagnostic criteria. To this end, the following questions are posed: i) Are the diagnostic criteria of DSM-IV and DSM-5 organized in a cluster of interrelated symptoms? ii) What is the relationship between the diagnostic criteria of "legal problems" and "craving" with the rest of the diagnostic criteria? and iii) Which of the criteria are most central to the diagnosis of cocaine use disorder?

**Methods**

*Participants*

The sample was composed of 425 patients diagnosed with SUD attending to public centres specializing in drug addiction care. To participate in the study, patients had to meet the following inclusion criteria: 1) the patients must have been diagnosed with alcohol, cannabis, cocaine, or heroin dependence according to DSM-IV criteria by a psychologist of the addiction centres; 2) the patients must not have had any mental retardation or other learning disorders; 3) the patients could read and write; and 4) the patients needed to sign the informed consent form.

The sociodemographic characteristics and the abuse and dependence profile of the patients are shown in Table S1.

A simulation analysis [26] was conducted to determine whether the sample size of the present study (n = 425) is adequate for the estimation of both networks (DSM-IV and

DSM-5). The procedure followed in the simulation analysis is explained in supplementary material section.

*Instruments*

*The Substance Dependence Severity Scale -SDSS-* [27]. To assess the severity of cocaine use disorders according to the DSM-IV, the seven diagnostic criteria for dependence were assessed through 11 items, and four items were used to evaluate the four diagnostic criteria for abuse. The Spanish version of this scale was developed for the DSM-IV and adapted to the DSM-5 [28]. Therefore, the diagnostic criteria related to craving were included in this version, whilst also maintaining an item that assesses legal problems.

Each item was evaluated on a scale from "absent" (0) to "extreme" (5), with a score equal to or greater than two taken to indicate the presence of the diagnostic criterion.

*Procedure*

A psychologist experienced in the evaluation of patients and trained in the administration of the SDSS was responsible for conducting the interviews in individual sessions in the centres where the participants received their treatment. All participants responded to all items. Therefore, there were no missing values.

Before the interview began, the patients were informed of the objectives of the study. It was explained to them that the information collected would be confidential and that the data would be used for statistical purposes and not for their therapeutic process. Once patients agreed to participate, they were then asked to sign an informed consent form. They were also told that they could withdraw from the study whenever they wished. At the end of the interview, patients were given a voucher to the value of 10 euros to spend in a supermarket (excluding the purchase of alcohol).

The ethics committee of the University of Huelva and the Committee on Ethics in Research Centres in Huelva (Andalusian public health service) approved the study.

*Analysis*

Univariate statistics were used to estimate the prevalence of cocaine use disorder criteria according to DSM-IV and DSM-5. The reliability of the different clusters of diagnostic criteria was estimated as internal consistency (omega coefficient [29]). Discrimination indices are also provided.

Several Confirmatory Factor Analyses (CFA) were applied to analyse the internal structure: Model 1: two unrelated factors -DSM-IV abuse vs dependence-, Model 2: two related factors -DSM-IV abuse vs dependence-, and Model 3: one factor -both DSM-IV (Model 3A) and DSM-5 (Model 3B); Model 4: one factor with 10 criteria (without craving or legal problems)". A robust parameter estimation method (Weighted Least Squares-Robust) was employed, given the binary nature of our data [30], using the "lavaan" package of R [31]. The criteria used to test the fit of the models are explained in supplementary material section.

The IRT analyses were conducted by applying 2-parameter logistic models. These analyses estimated the parameters of difficulty (severity), discrimination of the criteria (difference between people with CUD levels above/below the criterion's difficulty parameter), and the information function of the items (as reliability evidence). More information about the difficulty and discrimination parameters, as well as the information function and estimation method used, can be found in the supplementary material.

In network analysis, each node represents a diagnostic criterion, and each edge represents the relationship between two nodes. The values that are denoted by the weights of the edges are the regression parameters between the nodes [32]. Following

the recommendations of Van Borkulo et al. [33], the hyperparameter γ was set at .25 to generate a relatively parsimonious network reducing spurious edges to zero [26].

As centrality measures, strength and expected influence (EI) were estimated. As a measure of predictability, we used normalized accuracy ("nCC"). Finally, the stability of the centrality indices and the accuracy of the estimated networks were analysed. To examine network accuracy, the 95% confidence interval (CI) of the weights of each edge were estimated using nonparametric bootstrap with 1.000 bootstrapped samples. Further information on the interpretation and estimation procedure of these indexes is provided in the supplementary material.

**Results**

*Description of diagnostic criteria according to DSM-IV and DSM-5*

Table 1 shows the percentage of responses to the diagnostic criteria of dependence and abuse according to DSM-IV and DSM-5 diagnostic criteria. Prevalence of criteria ranged between 40% ("Quit/control") and 11% ("Hazardous use"). According to the DSM-IV diagnostic criteria, 23% presented diagnostic criteria compatible with cocaine dependence and 29% of abuse. When the "Legal problems" criterion was excluded, the percentage of patients showing abuse was 22%. According to DSM-5 diagnostic criteria, 34.9% of patients met the criteria compatible with the disorder, of which 11.1% were mild; 5.2% moderate; and 18.6% severe. Estimating the prevalence of SUD and excluding the craving criterion reduced the percentage of patients diagnosed to 29%. Therefore, the inclusion of the craving criterion lead to a significant increase in prevalence ($t_{(424)}$=5.26, p < .001).

In terms of internal consistency, omega (ω) coefficients for seven dependence criteria (DSM-IV) showed an ω value of .90, with discrimination indices ranging from r=.59 to r=.75. The four abuse criteria showed an internal consistency of ω=.69, and the lowest

discrimination index corresponded to "Legal problems" (r = .31). In the absence of the diagnostic criterion "Legal problems" the estimated internal consistency reached ω=.72. Internal consistency of the 11 diagnostic criteria of DSM-IV was ω= .91. This value remained unchanged when the "Legal problems" criterion was excluded.

The internal consistency for the 11 DSM-5 diagnostic criteria was ω=.92, with discrimination indices between r=.53 and r=.77.

*Factor Analyses*

Confirmatory factor analyses revealed that the distinction between two uncorrelated factors (DSM-IV abuse and dependence) showed a poor fit (Model 1: CFI = .59; NNFI = .48; RMSEA = .246; Robust/$\chi^2$= 1604.33, p < .001). However, the fit indices improved when estimating the correlation between the two dimensions (Model 2: CFI = .99; NNFI = .99; RMSEA = .024; Robust/$\chi^2$= 79.82, p < .01). The fit of Model 2 was significantly better than the fit of Model 1 (Table S2). The high correlation between the two DSM-IV dimensions (r = .99) constitutes clear evidence to suggest a one-dimensional structure of the 11 criteria of both the DSM-IV and DSM-5.

Table 1 shows the fit and factor loadings in the unidimensional model for the DSM-IV and DSM-5 criteria. The diagnostic criterion "Legal problems" had the lowest factor loading (<.45). The remaining DSM-IV factor loadings ranged from .57 to .81. CFA for the 11 diagnostic criteria of the DSM-5 revealed that the "craving" criterion was integrated into the SUD dimension with a high factor loading (.75). The remaining factor loadings ranged from .59 to .81. However, neither of the two models with 11 criteria (3A or 3B) improved the fit rates of the model with only 10 criteria (Model 4).

***INSERT TABLE 1***

*IRT Analyses*

As a preliminary step, we verified compliance with the assumptions of unidimensionality and local independence by analysing the standardized residuals. Given that in both unifactor models (3A: DSM-IV and 3B: DSM-5) we found that only one of the 55 standardized residuals (1.8%) was greater than 0.10, we can confirm that the assumptions of unidimensionality and local independence have been met.

Table 2 shows the severity parameter of diagnostic criteria along the CUD continuum. (Table S3 shows the difficulty and discrimination parameters, as well as their standard errors and model fit). It appears that the "Quit/Control" criterion had the lowest values. In contrast, and with the exception of the criterion "Legal problems" ($b$=1.55), "Hazardous use" was the criterion with the highest severity parameters (between $b$=1.51 and $b$=1.52). With respect to the item discrimination parameters (Table S3), almost all were high, ranging from a =2.55 for "Hazardous use (DSM-5 model)" to $a$ =5.43 for "Time spent (DSM-IV model)". The lowest discrimination parameter was found for the "Legal Problems" criterion ($a$ =1.52).

***INSERT TABLE 2***

Table 3 displays the total information area (TIA). Based on the seven dependency criteria, neither "Legal problems" or "Craving" produced a significant increase in TIA. The TIA increased significantly when these diagnostic criteria were introduced, along with the other three abuse criteria.

***INSERT TABLE 3***

*Network analyses*

The exploratory graph analysis (Figure 1) for the DSM-IV and DSM-5 criteria offers an optimal community structure solution that groups all the diagnostic criteria together. In

both networks, the strength and EI values of the diagnostic criterion “Quit/control” were significantly different compared to the remaining diagnostic criteria. In contrast, the network representation of the DSM-IV shows that the criterion "Legal problems" had the lowest strength and EI values, which is compatible with its external position in the network. In the DSM-5 network, the criterion "Social/Interpersonal problems" had the lowest values in these centrality indices. The rest of the diagnostic criteria had similar values.

Moreover, the strength and EI values show that the abuse criteria are no less important or central than the dependency criteria. In the DSM-IV model, for example, criterion "Social/Interpersonal problems" occupied more central positions —having strong connections with “Quit/control” and “Time spent” with high weights and centrality values — in comparison with “Tolerance” or “Phys./Psych. Problems”. Further, in this same model, criterion “Neglect roles” yielded higher centrality values than these dependency criteria. In the DSM-5 model, the same criterion, “Neglect roles”, had higher centrality values than six of the seven dependency criteria.

The predictability values are shown in Table 2. From the *Ncc* values it is clear that the explained variance was low for certain diagnostic criteria of the DSM-IV and DSM-5. It should be noted that the *Ncc* value for the criterion "Legal problems" was 0, indicating no contribution from the other variables. In both models, it is also observed that the diagnostic criteria with lowest contribution are “Hazardous use” and “Tolerance”.

Regarding stability analyses, the CS-coefficient (r = .7) for Strength was .36 in the DSM-IV network, and .21 in the DSM-5 network. The CS-coefficient (r = .7) for EI was .28 in the DSM-IV network, and .13 in the DSM-5 network. These results indicate that the stability and interpretability of the estimates were moderate in the DSM-IV network and insufficient in the DSM-5 network. This implies that the centrality

measures for the latter network might be more susceptible to sample-dependent variation [34]. The bootstrapped CIs of the estimated edge weights are shown in Supplementary Figure 3. The amplitude of the CIs suggests that the order of the edge weights should be interpreted with caution [34]. The significant differences between edge weights and node strength are shown in Supplementary Figures 4 and 5 respectively. The bootstrapped CI of the "Quit/control-Craving" edge (DSM-5 network) did not overlap with the majority of the bootstrapped CI of the rest of the edges present in the network, with the strength of this edge being significantly greater than that of the majority of the edges. However, the strength value of node "Quit/control" was significantly higher than that of the rest of the nodes in both networks (DSM-IV and DSM-5). At the same time, the strength of the "Legal problems" node was significantly lower than that of the other nodes in the DSM-IV network.

***INSERT FIGURE 1***

**Discussion**

This paper aimed to provide a more in-depth understanding of the relationships between the diagnostic criteria of CUD. To this end, we replicated the factor and IRTs analyses that have been conducted in previous studies, and, for the first time, network analysis was applied to a clinical sample in order to compare the criteria of the DSM-IV with those of the DSM-5.

While applying network analysis entails understanding mental disorders as the direct interaction between symptoms [17], factor analysis and IRT assume the existence of a latent factor that explains the various symptoms. Thus, as Marsman et al. [35] pointed out, the relationships can be interpreted as direct links between the symptoms (network analysis), or by assuming the existence of a common cause that explains the different symptoms (factor analysis and IRT). In spite of these conceptual differences, this study

indicates a certain degree of convergence between the results found with the different techniques applied.

Our findings support the existence of a one-dimensional structure of the SUD criteria when using both factor analysis [9,11] and IRT models [7]. In addition, network analyses revealed that the diagnostic criteria form a single community of relationships, as other authors have found [22, 25]. Thus, there appears to be a correspondence between the single community identified by network analysis and the one-factor structure of the factor analysis.

With respect to the criterion "Legal problems", our results provide support for the exclusion of this criterion by finding: a) low prevalence and negative impact on internal consistency; b) low factor loadings; and, c) little added information on the basis of IRT analysis. Furthermore, in network analysis it has been observed that this criterion occupies a peripheral position in the network, being exclusively related to "Quit/control" and only weakly related to "Withdrawal". This result is partially congruent with the results obtained by Rhemtulla et al. [25], who found that, in their network analysis representing all substance classes, "legal consequence" was the criterion with the lowest centrality indices. However, in the specific cocaine network, the centrality of "legal consequences" was similar to that of other diagnostic criteria.

In line with other authors [7,14], we have found that the inclusion of "Craving" does not produce a significant gain in terms of accuracy. However, from the perspective of network analysis, this criterion shows significant centrality indices, having strong relationships with the "Quit/control", "Withdrawal" and "Social/interpersonal problems" criteria. This contribution of network analysis is relevant in at least two ways. First, we consider that provide empirical evidence of the content validity of the CUD diagnosis

and, second, it empirically shows how craving is closely linked to the central criterion of the network.

In the network detected in this study, the "Quit/control" criterion showed significantly greater centrality indices than the remaining diagnostic criteria. This criterion is strongly related to social deterioration ("Neglect roles" and "Activities given up") and physiological symptoms ("Craving" and "Tolerance"). Compared with the network of the study conducted by Rhemtulla et al. [25] with consumers in the general population, both similarities and differences are found. In terms of similarities, these authors found another criterion related to poor control over consumption ("use more than planned: Larger/Longer") to be central. Similarly, this criterion had a strong relationship with the "Activities given up" and "Tolerance" criteria. Among these differences, in the study by Rhemtulla et al. [25] the criterion "Quit/control" is peripheral and has little centrality. Furthermore, in our study the criterion "Larger/Longer" presents average centrality values. Thus, conceptually, it can be seen that in both studies the criteria related to loss of control are those that have the greatest influence on the other criteria, particularly on the consequences of consumption. The differences in the centrality of the criteria related to loss of control may be due to the different samples used in each study. In non-treatment users, the centrality of the "Larger/Longer" criterion could be a consequence of the impulsivity that characterizes the early phases of consumption; in patients, however, the centrality of "Quit/control" largely represents the compulsiveness of those with the addictive disorder [36].

From a clinical perspective, network analyses reveal complex interactions between diagnostic criteria. However, it may be useful to carefully analyse the relationships between criteria in order to reduce the severity of the dependency. In this regard, several studies suggest that intervention on nodes with high values of strength, EI and

predictability could generate global changes in the network, and these are therefore considered to be targets for intervention [20,37]. From this perspective, for intervention with these patients it would be necessary to develop strategies to provide them with personal skills that would allow them to control their consumption (acting on "Quit/control"), which would result in an improvement in other criteria.

Regarding limitations, in our study we used the SDSS adapted to the DSM-5, which assesses the criteria during the month prior to the interview. In contrast, in both DSM-IV and DSM-5 the reference time frame is the past year. This limits the comparability of our results with those of previous works, as well as their extrapolation to these diagnostic systems. However, using a 30-day time frame produces gains in validity by minimizing memory bias, as well as providing advantages from a clinical perspective.

Further, we would like to point out the limitation concerning the gender distribution of our sample, which was 85.4% male. This imbalance does not allow us to estimate the invariance of the network with sufficient statistical certainty. However, the percentage of men and women analysed was similar to the gender distribution found in the demand for treatment for drug use in Spain [38]. Another limitation related to the sample is associated with its heterogeneity with respect to dependence on different drugs. In this regard, it is unknown whether patients could form latent classes within the sample, and how this may impact on IRT and network parameters, as well as the CFA factor loadings. While the answer to these questions should be addressed with mixture modelling analysis, this would exceed the scope of the present study. Therefore, the results should be interpreted with caution.

In relation to the network analysis, one limitation is that the centrality measures showed low stability, particularly in the case of the DSM-5 network. It should be noted that none of the previous studies of network analysis in SUD [22-25] provide results on the

stability of these measures. In this sense, it could be useful for future studies to analyze whether the measure of centrality may vary according to the sample. Besides this, according to Borsboom [16], the analysis of an individual's symptom-symptom interactions should form the basis for the development of interventions, along with any external variables or conditions (e.g., adverse life events) that could influence network symptoms. In this sense, it would be advisable to develop future network analyses based on within-person conditional dependencies over time in order to identify possible intervention targets more precisely [39,40].

In conclusion, we believe that the present study makes use of novel network analysis models, which provide information about the interconnection between all of the criteria. Furthermore, our data are compatible with those of other studies in pointing out the inadequacy of the “Legal problems” criterion, while "Craving" appears to be adequately integrated into the DSM-5 proposal. Further, the network analysis described here has provided useful information for planning therapeutic strategies based on the relationships between the criteria. Although the cross-sectional design does not allow for the establishment of causality between such relationships, we consider it to be a starting point for the design of longitudinal studies that could delve deeper into this issue.

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**Table 1.**

*Prevalence and factor loadings of the one-dimensional model (Confirmatory Factor Analysis; WLS-Robust estimation) for cocaine use disorder criteria.*

| | | Model 4: 10 criteria | Model 3A: DSM-IV | Model 3B: DSM-5 |
|---|---|---|---|---|
| | Prevalence (%) | Factor Loadings | Factor Loadings | Factor Loadings |
| D1. Larger/Longer | 16 | .73 | .73 | .72 |
| D2. Quit/Control | 40 | .69 | .70 | .73 |
| D3. Time spent | 18 | .81 | .81 | .79 |
| D4. Activities given up | 15 | .78 | .77 | .76 |
| D5. Tolerance | 10 | .60 | .60 | .59 |
| D6. Withdrawal | 25 | .79 | .79 | .81 |
| D7.Phys./Psych.Problems | 17 | .79 | .78 | .78 |
| A1. Neglect roles | 13 | .72 | .71 | .70 |
| A2. Hazardous use | 11 | .57 | .57 | .57 |
| A3.Social/Interp.Problems | 13 | .72 | .71 | .72 |
| A4. Legal Problems | 16 | --- | .42 | --- |
| Craving | 31 | --- | --- | .75 |
| Model fit | NNFI | .99 | .99 | .99 |
| | CFI | .99 | .99 | .99 |
| | RMSEA | .018 | .023 | .033 |
| | 90%CI for the RMSEA | .000/.027 | .015/.031 | .027/.040 |
| | SRMR | .037 | .040 | .045 |
| | BIC* | 1477.78 | 1772.15 | 1767.84 |
| | Robust/$\chi^2$ | 54.79 | 80.42 | 129.39 |
| | *df* | 35 | 44 | 44 |
| | *p* | .018 | .001 | .000 |

Robust/$\chi^2$= Robust chi-square; *df* = Degrees of Freedom; CFI = Comparative Fit Index; NNFI = Non-Normed Fit Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean-Square Residual; BIC = Bayesian Information Criterion (*Maximum Likelihood-Robust estimation); WLS =Weighted Least Squares; D1 to D7 = DSM-IV dependence criteria; A1 to A4 = DSMIV abuse criteria.

**Table 2.**
*Predictability measures (network analysis) and item response severity (IRT analysis) of cocaine use disorder criteria*

| | IRT Analysis | | Network Analysis | | | |
|---|---|---|---|---|---|---|
| | IRT Severity | | DSM-IV | | DSM-5 | |
| | DSM-IV | DSM-5 | Ncc | CCmarg | Ncc | CCmarg |
| D1. Larger/Longer | 1.16 | 1.17 | .39 | .84 | .39 | .84 |
| D2. Quit/Control | 0.19 | 0.19 | .68 | .60 | .72 | .60 |
| D3. Time spent | 1.03 | 1.04 | .58 | .82 | .60 | .82 |
| D4. Activities given up | 1.16 | 1.16 | .54 | .85 | .54 | .85 |
| D5. Tolerance | 1.51 | 1.52 | .12 | .90 | .10 | .90 |
| D6. Withdrawal | 0.75 | 0.74 | .62 | .75 | .61 | .75 |
| D7.Phys./Psych.Problems | 1.07 | 1.06 | .50 | .83 | .51 | .83 |
| A1. Neglect roles | 1.27 | 1.27 | .39 | .87 | .39 | .87 |
| A2. Hazardous use | 1.51 | 1.52 | .06 | .89 | .08 | .89 |
| A3.Social/Interp.Problems | 1.27 | 1.27 | .33 | .87 | .25 | .87 |
| A4. Legal Problems | 1.55 | - | .00 | .84 | - | - |
| Craving | - | 0.52 | - | - | .57 | .69 |

Ncc = Normalized accuracy; CCmarg = accuracy of the intercept (marginal) model;
D1 to D7 = DSM-IV dependence criteria; A1 to A4 = DSMIV abuse criteria.

**Table 3.**

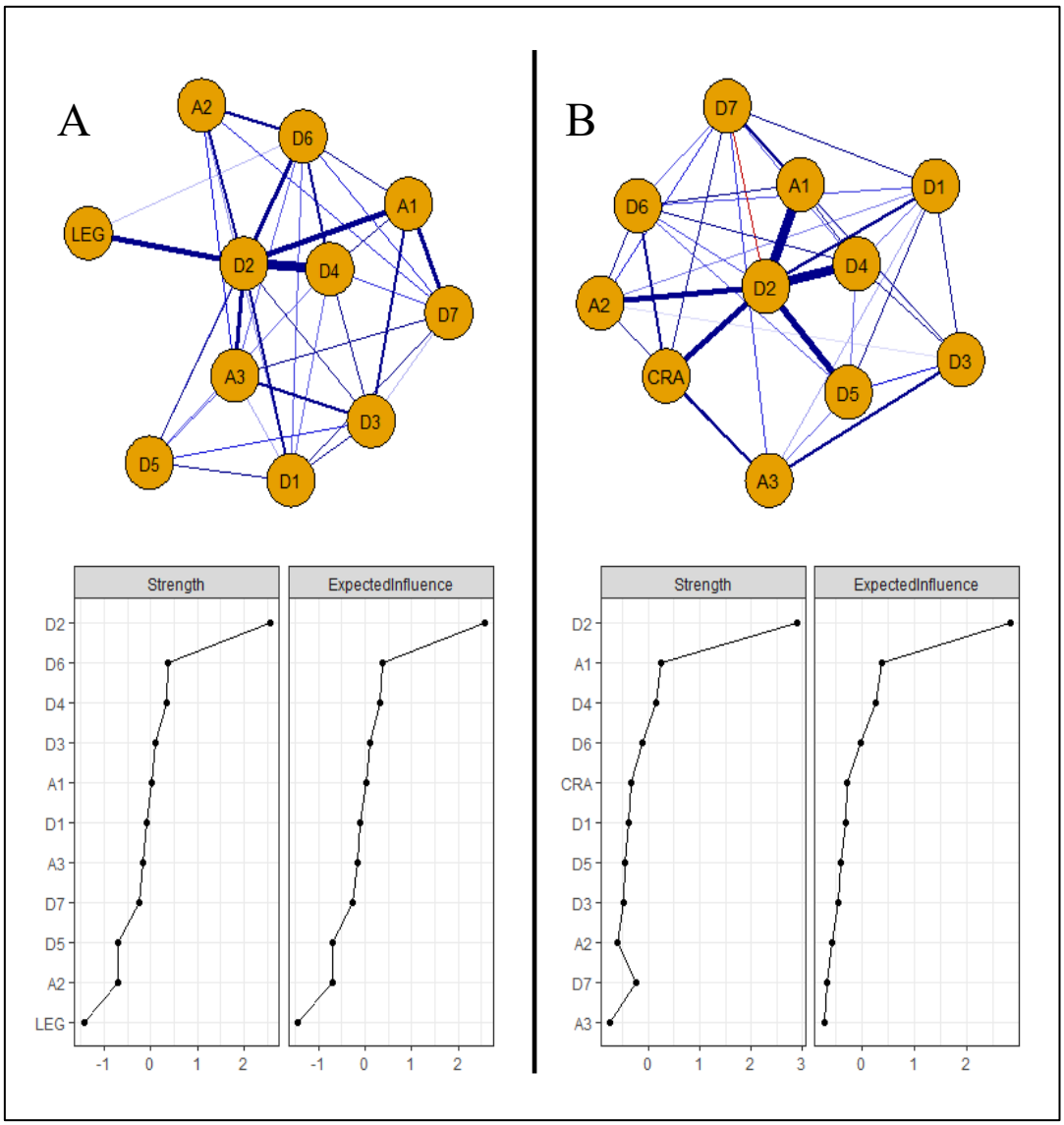
*Total Information Area (TIA) and 95% confidence interval*

| Criteria | No. of criteria | TIA | 95% confidence interval | |
|---|---|---|---|---|
| Dependence | 7 | 29.92 | 25.13 | 34.70 |
| Dependence + Legal Problems | 8 | 33.09 | 27.56 | 38.60 |
| Dependence + Craving | 8 | 33.63 | 28.94 | 38.33 |
| Dependence + Abuse | 10 | 42.37* | 35.49 | 49.25 |
| Dependence + Abuse + Legal Problems | 11 | 46.21* | 37.98 | 54.44 |
| Dependence + Abuse + Craving | 11 | 44.72* | 39.17 | 50.26 |

* $p < .05$ taking as a reference the TIA of dependence

**Figure 1:**

*Empirical network model and strength and expected influence of DSM-IV (A) and DSM-5 (B) for cocaine use disorder criteria.*




*Note*: The lines represent the relationships (partial correlations) between the symptoms. Positive relationships are represented in blue, and negative relationships in red. The thickness of the line indicates the strength of the association, so that the most strongly correlated symptoms are connected by thicker lines. D1=Larger/Longer, D2=Quit/Control, D3=Spent time, D4=Activities given up, D5=Tolerance, D6=Withdrawal(abstinence), D7=Phys/PsychProblems, A1=Neglect roles, A2=Hazardous use, A3=Social/Interp Problems, LEG=Legal Problems, CRAV=Craving.
In both networks, the diagnostic criterion “D2 Quit/control” is the most influential diagnostic criterion within the network. In contrast, the DSM-IV criterion "PROB Legal problems" has an external position in the network. In the DSM-5 network, the criterion "A3 Social/Interpersonal problems" is most distant and least related to the remaining network criteria.

**SUPPLEMANTARY MATERIAL**

## Methods

*Participants*

Of the sample, 85.4% were male (mean age 39.6 [SD=10.76]). Most of the patients had completed primary education (44.7%) and 15.5% reported having completed university studies. More than half (53.4%) of the participants were unemployed at the time of the interview, and 20.2% were in full-time employment. Of the patients, 22.6% were pensioners (Table S1). 71.6% of patients had criteria compatible with cocaine abuse or dependence in the past months; 35.1% with alcohol abuse/dependence problems; 30.5% with cannabis abuse/dependence; and 10.6% with heroin abuse/dependence.

In order to determine whether the sample size of the present study is adequate for the estimation of both networks, the correlation between the values of the weights of the edges, sensitivity (the proportion of genuine connections that are correctly estimated to be present, known as the true positive rate), specificity (the proportion of absent connections that are correctly estimated to be zero, also referred to as the true negative rate) [1], strength, and expected influence obtained in the "real" network and those obtained in the simulated networks with different sample sizes (n = 250, 425, 500, 1000) repeated 1000 times was estimated. Correlation values obtained between the real and the estimated network of 425 cases were greater than r = .70 for the weights of the edges, sensitivity, specificity, strength, and expected influence (see supplementary Figures1 and 2). Only the sensitivity of the DSM-IV network showed a slightly lower value (r = .64).

*Analysis*

Several Confirmatory Factor Analyses (CFA) were applied to analyse the internal structure. To determine the model fit, in addition to Robust $\chi^2$ (Robust/$\chi^2$), we employed the following fit indices that are least affected by sample size: Comparative Fix Index (CFI), Non-Normed Fi T Index (NNFI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean-Square Residual (SRMR), Aikake Information Criteria (AIC) and Bayesian Information Criterion (BIC). CFI and NNFI values close to .90 or .95 are taken to indicate a good fit; RMSEA and SRMR < .05 indicates good fit, and values between 0.05-0.08 indicate an acceptable fit; AIC and BIC compare alternative models and lower values indicate a better fit [2]. In addition, the standardized residuals [3] of models 3A and 3B were analysed. If the absolute values of these residuals were less than .10 then this is taken to indicate that the assumptions of unidimensionality and local independence of the IRT models were fulfilled.

In Item Response Theory analysis, the severity parameters of the diagnostic criteria reflect their location on the underlying trait. The severity parameter is expressed on the standardized scale (M = 0, SD = 1), and corresponds to the value on the underlying trait where the probability of endorsing the response category is .50. The typical range of values is between +/- 2, although these frequently exceed +/- 3 in clinical measurement. Higher scores indicate a higher level of the underlying trait. Discrimination (slope) parameters reflect the strength of the relationships of each diagnostic criterion with the underlaying trait. The usual range of discrimination parameter values is between +/- 2.8. In the context of the measurement of clinical variables, more extreme values can be found. Higher values of the parameter indicate a higher discrimination ability of the diagnostic criterion [4-7]. The information function is the inverse of the standard error of estimate and reflects the precision about the location of a person (or an item) at a

particular level of the underlying trait. Information (I) can be converted to a standard measure of reliability rxx' = 1- (1/I) [8].

The difficulty and discrimination parameters were obtained by means of a marginal maximum likelihood (MML) procedure using the "ltm 1.1.1" package of R3.6.1 [9]. To analyse the extent to which the increase in diagnostic criteria provides relevant information, the Total Information Area (TIA) [10] was calculated. The significant increase in TIA was analysed using the confidence intervals (95%) of the total area. The delta method program was used for this purpose (developed by Melanie M. Wall and available at http://www.columbia.edu/~mmw2177/IRT/irtprog.html).

In network analysis, only strength and expected influence (EI) were estimated as centrality measure because betweenness and closeness present theoretical and empirical limitations that question their interpretability and usefulness in the field of psychological networks [11-13]. Measures of Strength centrality and Expected Influence (EI) reflect the degree to which a given node relates to the rest of the nodes [14]. As a measure of predictability, we used normalized accuracy ("nCC"). This indicates the extent to which the node in question can be predicted by the rest of the nodes in the network, beyond what is randomly predicted by the marginal distribution [15]. This measure takes values between 0 and 1, where 0 indicates that none of the other nodes adds anything to the marginal when predicting the node in question, while 1 indicates that all of the remaining nodes perfectly predict the node. Finally, the stability of the centrality indices and the accuracy of the estimated networks were analysed. The stability of the network centrality indices was evaluated by means of a person-dropping bootstrap procedure that provides a correlation-stability coefficient (CS- coefficient). CS-coefficient values > .25 indicate moderate stability and interpretability of the network, and > .5 indicate strong stability and interpretability [13]. To examine network

accuracy, the 95% confidence interval (CI) of the weights of each edge were estimated using nonparametric bootstrap with 1.000 bootstrapped samples. Larger CIs indicate reduced precision in the estimation of the edges while narrower CIs imply a more trustworthy network [13]. Significant differences between network edges and node strengths were also estimated using non-parametric bootstrapping.

SPSS 24.0 was used for descriptive analysis and internal consistency. The structure of the network and its graphical representation was obtained through the R packages "IsingFit" 0.3.1 [16] and "qgraph" 1.6.4 [17]. To detect the community structures, the walktrap algorithm was applied using the R package "igraph" 1.2.4.2 [18]. The "qgraph" 1.6.4 package [17] was used to estimate strength centrality and EI, and the package "mgm" 1.2.7 [19] was used to estimate the predictability of each node. For the network simulation analysis, and the analysis of the stability of the centrality indices and network accuracy, the R package "bootnet" 1.3 [13] was used.

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**Table S1.** Demographic and abuse/dependence variables

| Variable | N | % | Mean (S.D.) |
|---|---|---|---|
| *Gender (Males)* | 363 | 85.4 | |
| *Age* | 425 | | 39.60(10.76) |
| *Education Level* | | | |
| No studies | 70 | 16.5 | |
| Primary Education | 190 | 44.7 | |
| Secondary Education | 99 | 23.3 | |
| Higher Secondary Education | 48 | 11.3 | |
| University | 18 | 4.2 | |
| *Employment Situation* | | | |
| Employed | 86 | 20.2 | |
| Unemployed | 227 | 53.4 | |
| Retired | 4 | 0.9 | |
| Disability pension | 96 | 22.6 | |
| Penitentiary Institutions | 12 | 2.8 | |
| *Marital Status* | | | |
| Single | 278 | 65.4 | |
| Married | 51 | 12.0 | |
| Separated | 35 | 8.2 | |
| Divorced | 49 | 11.5 | |
| Widower | 11 | 2.6 | |
| *Abuse or dependence* | | | |
| Cocaine | 31 | 71.6 | |
| Alcohol | 15 | 35.1 | |
| Cannabis | 13 | 30.5 | |
| Heroin | 5 | 10.6 | |

**Table S2.** Supplementary Table 2: Model fit indices and chi-square test results for nested models (robust parameter estimation method, WLS-Robust)

| | | Fit Indices | | | | | | | | Robust/χ2 difference test* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model | Robust/χ2 | df | *p* | CFI | NNFI | RMSEA | 90%CI for the RMSEA | SRMR | BIC** | ΔRobust/χ2 | Δdf | *p* |
| Model 1: 2 uncorrelated factors (DSM-IV) | 1604.33 | 44 | .000 | .59 | .48 | .246 | .236/ .256 | .304 | 2660.69 | -- | -- | - |
| Model 2: 2 correlated factors (DSM-IV) | 79.82 | 43 | .001 | .99 | .99 | .024 | .015 / .032 | .040 | 1776.68 | 42.14 (2 vs 1) | 1 | .000 |
| Model 3A: 1 factor (DSM-IV) | 80.42 | 44 | .001 | .99 | .99 | .023 | .015 / .031 | .040 | 1772.15 | -- | -- | - |
| Model 3B: 1 factor (DSM-5) | 129.39 | 44 | .000 | .99 | .99 | .033 | .027 / .040 | .045 | 1767.84 | -- | -- | - |
| Model 4: 1 factor (10 criteria: "Legal problems" and "Craving" excluded) | 54.79 | 35 | .018 | .99 | .99 | .018 | .000 / .027 | .037 | 1477.78 | -- | -- | - |

Note: * Estimation of ΔRobust/χ2 (Robust/χ2 difference test) and *p* have been performed using the Satorra-Bentler's formula (Satorra & Bentler, 2010) developed in http://www.statmodel.com/chidiff.shtml. ** BIC: Maximum Likelihood-Robust estimation. *df* = Degree of Freedom; CFI = Comparative Fit Index; NNFI = Non-Normed Fit Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean-Square Residual; AIC = Akaike Information Criterion; WLS =Weighted Least Squares.

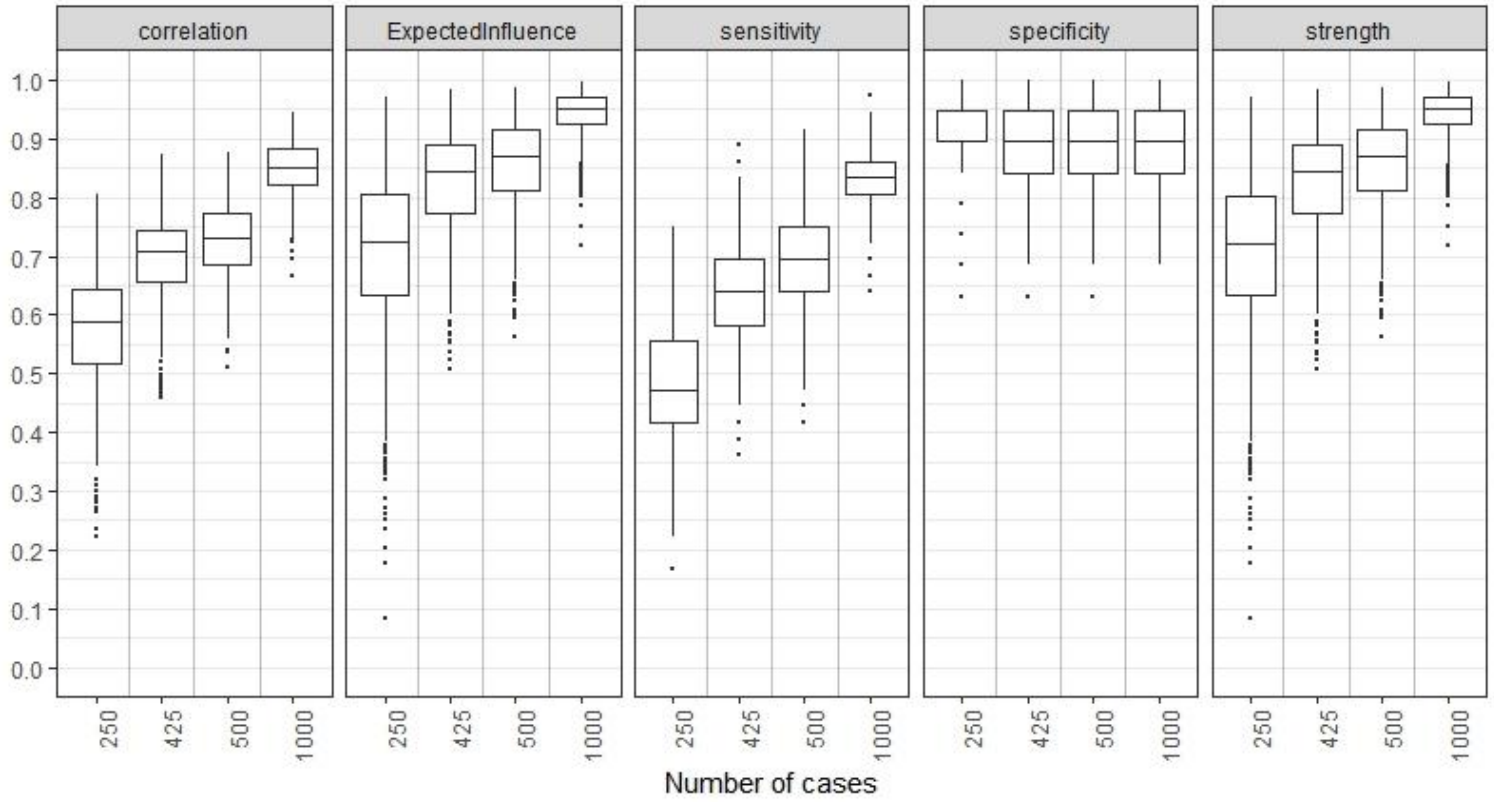
**Table S3** Supplementary Table 3. IRT Parameters (standard error of the mean)

| | DSM-IV | | DSM-5 | |
|---|---|---|---|---|
| | Discrimination (*a*) | Severity (*b*) | Discrimination (*a*) | Severity (*b*) |
| D1. Larger/Longer | 3.88(0.61) | 1.16(0.06) | 3.66(0.55) | 1.17(0.06) |
| D2. Quit/Control | 4.98(1.01) | 0.19(0.07) | 4.55(0.71) | 0.19(0.07) |
| D3. Spent time | 5.43(0.89) | 1.03(0.05) | 4.70(0.71) | 1.04(0.06) |
| D4. Activities given up | 5.39(1.05) | 1.16(0.04) | 4.98(0.86) | 1.16(0.09) |
| D5. Tolerance | 3.82(0.91) | 1.51(0.09) | 3.60(0.75) | 1.52(0.09) |
| D6. Withdrawal (abstinence) | 3.58(0.48) | 0.75(0.06) | 3.75(0.48) | 0.74(0.06) |
| D7. Phys/Psych Problems | 4.66(0.81) | 1.07(0.05) | 4.48(0.71) | 1.06(0.06) |
| A1. Neglect roles | 5.35(2.05) | 1.27(0.05) | 4.29(0.87) | 1.27(0.06) |
| A2. Hazardous use | 2.66(0.43) | 1.51(0.10) | 2.55(0.43) | 1.52(0.10) |
| A3. Social/Interp Problems | 4.63(0.84) | 1.27(0.05) | 4.72(0.87) | 1.27(0.06) |
| A4. Legal Problems | 1.52(0.23) | 1.55(0.16) | | |
| Craving | | | 3.35(0.42) | 0.52(0.07) |
| Log-Likelihood (df=22) | -1303.84 | | -1290.25 | |
| AIC | 2651.67 | | 2624.51 | |
| BIC | 2740.82 | | 2713.65 | |

Df = Degree of Freedom; AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion

**Figure S1.**

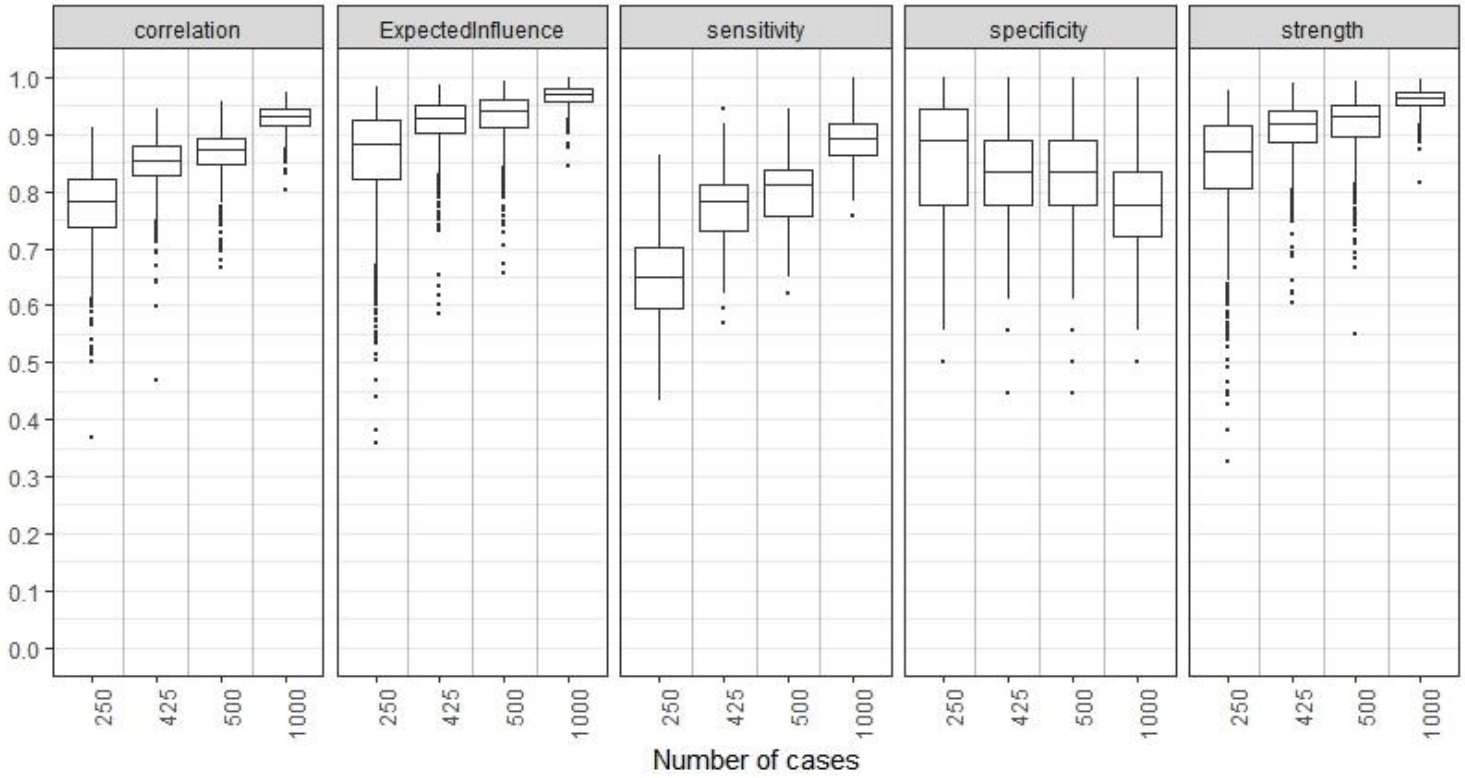
*Results of the simulation analysis for the DSM-IV network.*



*Note*. Simulation results using the estimated DSM-IV network adjusted to a real network structure for the complete sample (n = 425). This shows the correlation between the real network and the estimated network, the sensitivity (real positive rate), the specificity (real negative rate), and the correlation between the Strength and Expected Influence measures of centrality and the real network and estimated network.

**Figure S2.**

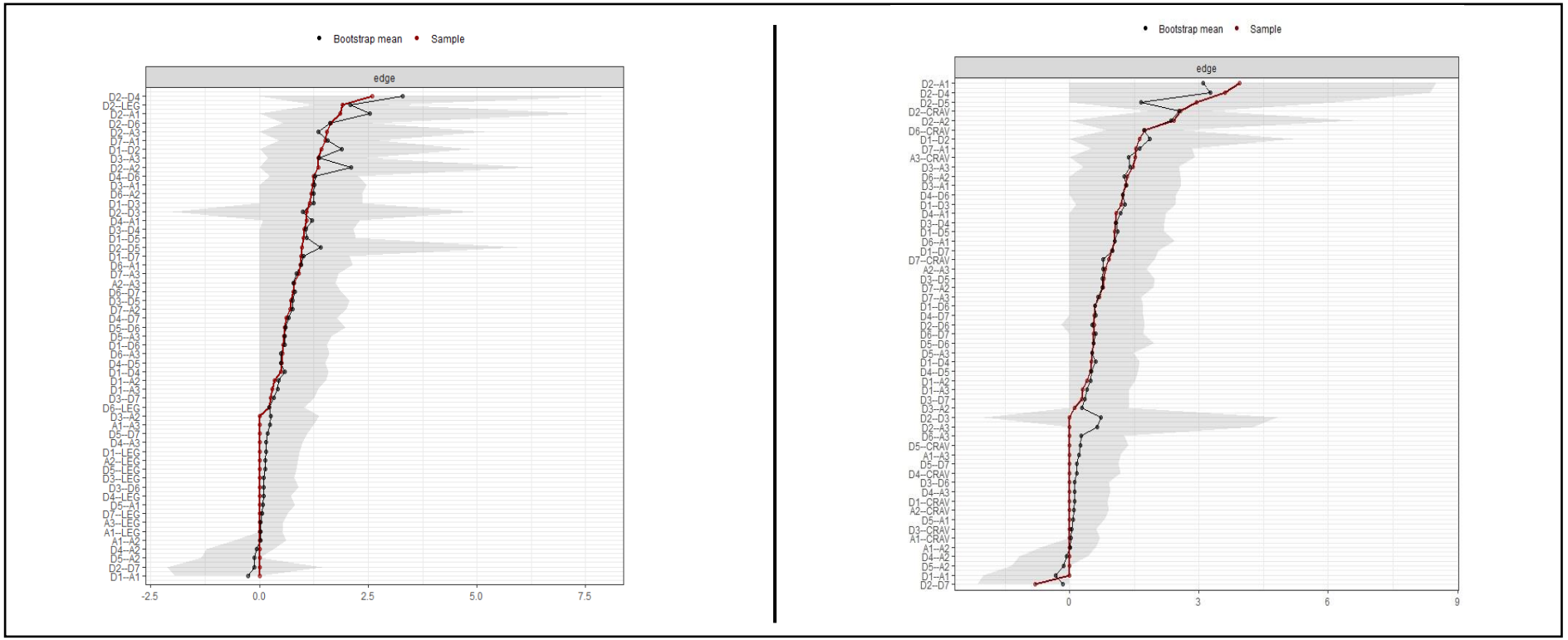
*Results of the simulation analysis for the DSM-5 network.*



*Note*. Simulation results using the estimated DSM-5 network adjusted to a real network structure for the complete sample (n = 425). This shows the correlation between the real network and the estimated network, the sensitivity (real positive rate), the specificity (real negative rate), and the correlation between the Strength and Expected Influence measures of centrality and the real network and estimated network.

**Figure S3.**

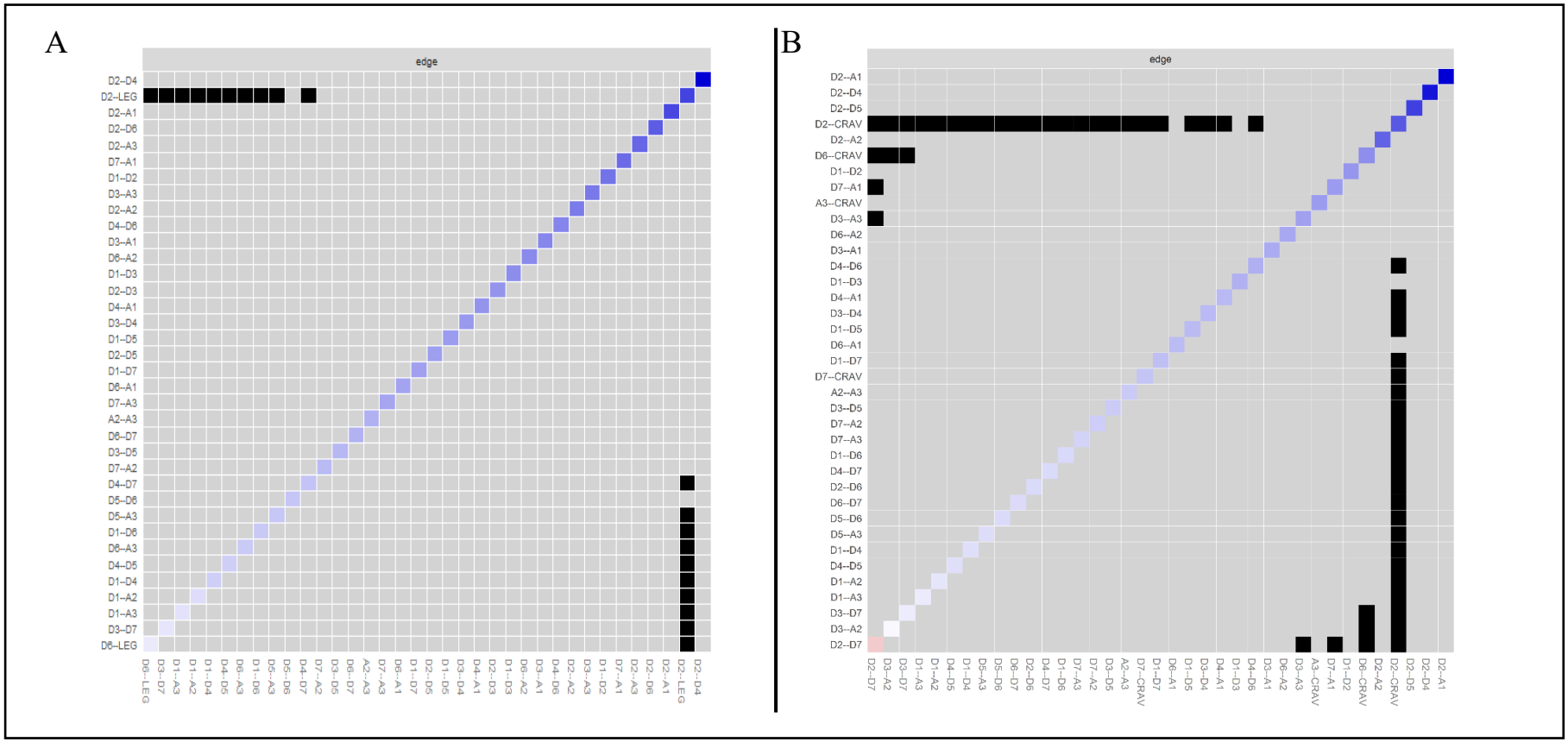
N*onparametric bootstrapped confidence intervals of estimated edges for DSM-IV (A) and DSM-5 (B) for cocaine use disorder criteria networks.*




*Note.* The red line represents sample values (estimated edges), while the black line represents bootstrap means. The grey area indicates the 95% bootstrapped confidence intervals. Each horizontal line represents one edge of the network, ordered from the edge with the highest edge-weight to the edge with the lowest edge-weight. D1: Larger/Longer; D2: Quit/Control; D3: Time spent; D4: Activities given up; D5: Tolerance; D6: Withdrawal; D7: Physical/Psychological Problems; A1: Neglect roles; A2: Hazardous use; A3: Social/Interpersonal Problems; LEG: Legal Problems; CRAV: Craving.

**Figure S4.**

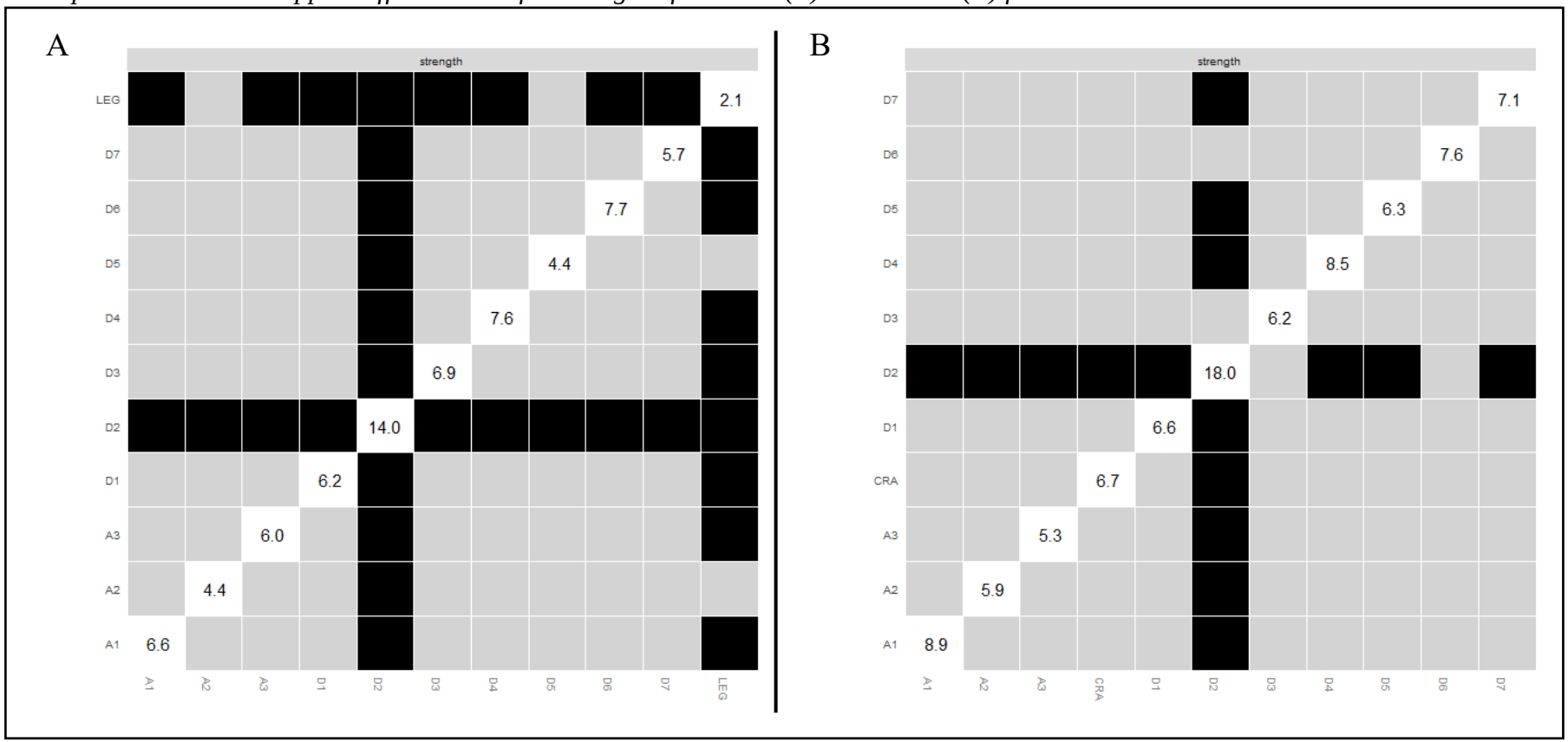
*Nonparametric bootstrapped difference test for edges of DSM-IV (A) and DSM-5 (B) for cocaine use disorder criteria networks*




*Note*. Grey boxes indicate no significant differences, whereas black boxes indicate statistically significant differences ($p < 0.05$). Diagonal color and saturation represent the magnitude and direction of each estimated edge. D1: Larger/Longer; D2: Quit/Control; D3: Time spent; D4: Activities given up; D5: Tolerance; D6: Withdrawal; D7: Physical/Psychological Problems; A1: Neglect roles; A2: Hazardous use; A3: Social/Interpersonal Problems; LEG: Legal Problems; CRAV: Craving.

**Figure S5.**

*Nonparametric bootstrapped difference test for strength of DSM-IV (A) and DSM-5 (B) for cocaine use disorder criteria networks.*




*Note*. Grey boxes indicate no significant differences, whereas black boxes indicate statistically significant differences ($p < 0.05$). Diagonal values represent the strength score of each node. D1: Larger/Longer; D2: Quit/Control; D3: Time spent; D4: Activities given up; D5: Tolerance; D6: Withdrawal; D7: Physical/Psychological Problems; A1: Neglect roles; A2: Hazardous use; A3: Social/Interpersonal Problems; LEG: Legal Problems; CRAV: Craving.