Exploratory Graph Analysis of the Multidimensional Schizotypy Scale

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Abstract:

The present study examined the dimensional structure underlying the Multidimensional Schizotypy Scale (MSS) and its brief version (MSS-B). We used Exploratory Graph Analysis (EGA) to evaluate their dimensional structure in two large, independent samples ($n = 6265$ and $n = 1000$). We then used Confirmatory Factor Analysis (CFA) to compare the fit of the theoretical dimensions with the EGA dimensions. For the MSS, EGA identified four dimensions: positive schizotypy, two dimensions of negative schizotypy (affective and social anhedonia), and disorganized schizotypy. For the MSS-B, EGA identified three dimensions, which corresponded to the theorized positive, negative, and disorganized dimensions. Based on the MSS's EGA dimensions, we also estimated a four-factor model for the MSS-B. The CFA comparison found that the four-factor model fit significantly better than the theoretical three-factor model for both the MSS and MSS-B, providing support for the theoretical model and offering a more nuanced interpretation of the negative schizotypy factor. In addition, EGA also revealed that the positive and negative schizotypy dimensions of the MSS and MSS-B might be mediated by the disorganized dimension. Our findings offer new implications for future research on the MSS and MSS-B dimensions that may provide differential associations with interview and questionnaire measures.

Keywords: Schizotypy | Exploratory Graph Analysis | Factor analysis | Schizophrenia-spectrum disorders | Network analysis

Article:

1. Introduction

Schizotypy is a multidimensional construct that offers a promising framework for understanding the development and etiology of schizophrenia-spectrum psychopathology (Lenzenweger, 2010). Despite extensive evidence demonstrating the validity and utility of the construct of schizotypy, the proposed underlying structure has varied considerably across studies and measures (Kwapil and Barrantes-Vidal, 2015). Specifically, there has been disagreement regarding the

heterogeneous nature of the construct, as well as variability regarding the content and structure of the questionnaires developed to measure schizotypy (Gross et al., 2014). Previous factor analytic studies typically identified two to five dimensions of schizotypy; however, current conceptual models indicate that *positive*, *negative*, and *disorganized* schizotypy are the strongest supported dimensions (e.g., Cohen and Fonseca-Pedrero, 2017; Gross et al., 2014; Kwapil and Barrantes-Vidal, 2015). The dimensional structure of schizotypy is usually examined using confirmatory factor analysis (CFA).

More recently, psychometric network models, such as Exploratory Graph Analysis (EGA; Golino and Epskamp, 2017), have been used as an alternative method to identify the dimensional structure of constructs. When defining dimensions, psychometric network models do not rely on a priori assumptions but instead develop an emergent structure based on the data. EGA is exploratory in nature and allows constructs to be vetted by using a model that does not conform to a researcher's a priori beliefs; therefore, it's an ideal method to test or re-evaluate the theoretical structure of a construct. Evidence suggests that EGA has comparable or better accuracy identifying dimensions than traditional factor analytic methods (Golino and Demetriou, 2017; Golino and Epskamp, 2017; Golino et al., 2018). In the present study, we sought to evaluate the dimensional structure of the Multidimensional Schizotypy Scale (MSS; Kwapil et al., 2018b) and its brief version, Multidimensional Schizotypy Scale-Brief (MSS-B; Gross et al., 2018b), using EGA in two large samples.

1.1. Theoretical structure of the MSS and MSS-B

Questionnaire measures are widely used to assess schizotypy (see review by Kwapil and Chun, 2015). However, extant measures suffer from conceptual and empirical limitations, including not mapping on to current models of schizotypy, psychometric shortcomings, and outdated items. The MSS and MSS-B were recently designed to improve upon these limitations and provide theoretically-based and psychometrically sound assessments of positive, negative, and disorganized schizotypy—the three most commonly identified dimensions in the literature (American Psychiatric Association, 2013; Kwapil and Barrantes-Vidal, 2015; Tandon et al., 2009). These three dimensions have also been shown to be invariant across cultures (Fonseca-Pedrero et al., 2018c) and are representative of schizophrenia-spectrum disorders (Lenzenweger and Dworkin, 1996).

The positive dimension involves disruptions in the content of thought (e.g., magical ideation and delusions), perceptual oddities (e.g., illusions and hallucinations), and paranoia/suspiciousness. The negative dimension is characterized by diminished experiences and expression (e.g., alogia, anergia, avolition, anhedonia, and flattened affect). The disorganized dimension involves cognitive-behavioral disturbances in the organization and expression of thoughts and behavior. Before the MSS and MSS-B, most schizotypy scales captured components of one or more of these three dimensions, but none comprehensively measured this theoretical three-factor structure (e.g., Gross et al., 2014).

The development of the MSS and MSS-B adhered to comprehensive scale development guidelines (DeVellis, 2012), including the development of detailed trait specifications for each dimension that guided item development. Items were selected based on content validity, item

response theory (IRT), classical test theory (CTT), and differential item functioning (DIF). These methods were employed to overcome limitations of previous schizotypy scales and to produce new schizotypy scales based on a strong theoretical foundation that possessed robust psychometric properties. To date, the MSS and MSS-B have shown good reliability, high item discrimination, and negligible item bias for sex and ethnicity (Gross et al., 2018b; Kwapil et al., 2018b). Furthermore, initial studies support the construct validity of both the MSS (Kwapil et al., 2018a) and the MSS-B (Gross et al., 2018a). The utility of schizotypy, and more specifically the scales that measure it, however, depends on the clear articulation of its multidimensional structure (Kwapil and Barrantes-Vidal, 2015). Thus far, the three-dimensional structure of the MSS and MSS-B has yet to be rigorously investigated. To investigate this structure, we applied the network approach.

1.2. Network psychometrics

Network psychometrics is a rapidly developing field that has been applied to many psychopathological constructs, including schizotypy (Christensen et al., 2018b; Fonseca-Pedrero et al., 2018b). The psychometric network approach defines constructs (e.g., schizotypy) as complex systems, which arise from mutually reinforcing interactions between the construct's constituent elements (e.g., schizotypy items; Borsboom and Cramer, 2013; Schmittmann et al., 2013). This definition forms the foundation of the network theory of psychopathology, which suggests that symptoms can reinforce one another, be influenced by other factors (e.g., biological, environmental, and social mechanisms), and lead to self-sustaining states that persist at the level of disorder (Borsboom, 2017). This theory aligns with current assessments of schizotypy as the latent liability of schizophrenia spectrum disorders, where interactions with biological and environmental influences may facilitate transition into disorder (Isvoranu et al., 2016; Lenzenweger, 2018).

Psychometric network models consist of *nodes* which represent variables (e.g., MSS items) and *edges* or connections which represent relations between the nodes (e.g., partial correlations given all other nodes in the network). Partial correlations are the unique shared variance between nodes in the network, which typically shrink many relations near or to zero. Often larger relations that remain form *communities* (or sets of many connected nodes) in the network. These communities are shown to be mathematically equivalent to factors (Golino and Epskamp, 2017).

One network method, EGA, was recently developed to detect and discover these communities (Golino and Epskamp, 2017). EGA applies a Gaussian Graphical Model (Lauritzen, 1996), which is computed using the *graphical least absolute shrinkage and selection operator* (*glasso*; Friedman et al., 2008). Then, the walktrap community detection algorithm is applied to identify the dimensions of the network (Pons and Latapy, 2006). The walktrap algorithm uses "random walks" to identify the content and number of dimensions in the network. Random walks are steps or jumps from one node to another in the network. Each node is repeatedly used as a starting point, traversing over neighboring edges, with larger edge weights (i.e., partial correlation values) being more likely to be traversed. In this process, communities form based on a node's proportion of many, densely connected edges and few, sparsely connected edges.

The dimensions discovered by EGA are deterministic and require no direction from the researcher. Thus, EGA offers a potential advantage over other exploratory dimension reduction methods because the content and number of dimensions are immediately interpretable, without the need to interpret component loadings of individual items. Despite the deterministic allocation of items, researchers should still verify the theoretical consistency of item placement. In both simulation and real-world datasets, EGA has produced comparable or better accuracy in identifying dimensions than other more common dimension reduction methods (e.g., principal component analysis, factor analysis, parallel analysis; Golino and Demetriou, 2017; Golino and Epskamp, 2017; Golino et al., 2018). Moreover, EGA has been effective at replicating factor analytic findings (Bell and O'Driscoll, 2018) as well as discovering new dimensions of constructs (Christensen et al., 2018a).

An advantage of psychometric network models more generally is that they allow a representation of item-level relations that afford interpretations across hierarchical resolutions—that is, the influence of item-level relations can be understood between items, within and between dimensions, and at the level of the construct itself (Blanken et al., 2018; Letina et al., 2018). Latent variable approaches assume local independence, suggesting that items are independent given a latent variable (Edwards and Bagozzi, 2000). These latent variables may then be correlated amongst themselves or independently related given some superordinate latent variable (e.g., the construct). From this perspective, the hierarchical resolution of relations is discrete and lateral, meaning relations are only allowed at the level of latent variables and these relations only occur across this level but not above (i.e., construct-level) or below (i.e., item-level). By contrast, psychometric network models permit a continuous resolution of each variable's relations, occurring simultaneously rather than independently.

1.3. Present research

The goal of the present research was to validate the theoretical dimensional structure of the MSS and MSS-B in two large, independent samples. To do so, we implemented EGA to discover the dimensional structure of the MSS and MSS-B. Because EGA does not impose a priori assumptions about the dimensional structure of the scales, it stands as an exploratory test for whether the theoretical dimensions intended by the scales' developers are measured as intended. Then, we used CFA to compare the dimensions identified by EGA to the theoretical MSS and MSS-B dimensions. For all analyses, we expected to find three factors, corresponding to positive, negative, and disorganized schizotypy.

2. Methods

2.1. Participants

The two samples used in this study were the same large samples used to develop and cross-validate the MSS and MSS-B (Gross et al., 2018b; Kwapil et al., 2018b). In total, 8750 people were recruited from four universities and Amazon's Mechanical Turk (MTurk) over a two-year span. All participants completed candidate items for the MSS, and these items were refined and trimmed to produce the final full-length and brief scales. Extensive demographic and methodological information for both samples used in this study, as well as detailed information

about the development of the MSS and MSS-B can be found in Kwapil et al. (2018b) and Gross et al. (2018b). In short, participants with elevated scores on measures of inattentive and invalid responding ($n = 947$) or who did not complete half of the items were removed from the datasets ($n = 362$). As with previous studies using these datasets, participants who were 60 or older were dropped given that schizotypy studies primarily focus on younger participants at or near the age of greatest risk for developing schizophrenia-spectrum disorders, to avoid age related cognitive disruptions that might especially impact the disorganization subscale, and because only 176 (2% of the total sample) were age 60 years or older.

The final overall sample used in this study consisted of 7265 participants, divided into the scale development sample (Sample 1), consisting of 6265 participants (68.5% female, 71% Caucasian, 12% African American, $M_{age} = 26.4$, $SD_{age} = 10.4$) and the validation sample (Sample 2), consisting of 1000 participants (50% female, 70% Caucasian, 11% African American, $M_{age} = 26.7$, $SD_{age} = 10.2$).

2.1.1. Missing data

There were 8740 missing values across 959 participants in Sample 1 and four missing values across 3 participants in Sample 2. For all correlation matrices used in the dimension reduction analyses, we included all participants and estimated correlations using full information maximum likelihood using the *psych* (Revelle, 2018) package in *R* (R Core Team, 2018).

2.2. Materials

2.2.1. Multidimensional Schizotypy Scale

The development of the full version of the MSS began with a thorough review of existing schizotypy scales as well as generation of new items guided by eight subject matter experts and six non-expert reviewers. The final 77 items were selected after several administrations and extensive psychometric evaluation (i.e., IRT, CTT, and DIF; Kwapil et al., 2018a). The positive and negative subscales included 26 items each, and the disorganized subscale included 25 items. Item selection was based upon the derivation sample, whereas the cross-validation sample was used to assess the psychometric properties of the final inventory (Kwapil et al., 2018b).

2.2.2. Multidimensional Schizotypy Scale-Brief

Based on the psychometric properties of the items in the full version, MSS-B items were selected based upon low endorsement frequencies, high IRT item discrimination, low DIF parameters, high item-scale correlations within the intended dimension, and low item-scale correlations with the other dimensions (Gross et al., 2018b). Furthermore, items were selected to maintain the same content coverage in the analogous MSS and MSS-B subscales. The positive and negative subscales included 13 items each, and the disorganized subscale included 12 items.

2.2.3. Inattentive and infrequency responding

Along with the candidate schizotypy items, the 13-item Infrequency Scale (Chapman and Chapman, 1983) and the Attentive Responding Scale (ARS; Maniaci and Rogge, 2014), containing 6 infrequency items and 6 pairs of inattentive items, were administered. Participants were not included in the analyses if they scored three or above on the Infrequency Scale or the ARS total, or four or above on the ARS variable responding index.

2.3. Procedure

The IRB, across all four participating universities, approved the development and validation studies. Participants completed the online survey via Qualtrics, with university students receiving course credit and MTurk participants receiving $1.00 USD for compensation. The survey started with informed consent and demographic questions. Then, the schizotypy, infrequency, and ARS items were intermixed and presented in six blocks in random order.

2.4. Statistical analyses

2.4.1. Exploratory Graph Analysis

To evaluate the number of dimensions in the MSS and MSS-B, we applied EGA using the *EGA* package (Golino, 2018) in R, which uses the *igraph* (Csardi and Nepusz, 2006) and *qgraph* (Epskamp et al., 2012) packages to apply the walktrap and glasso methods, respectively. The glasso method was estimated using a penalized maximum likelihood solution based on the extended Bayesian information criterion (EBIC; Chen and Chen, 2008; Epskamp et al., 2018).

2.4.2. Network construction

In these network analyses, nodes represent the individual items in the MSS and MSS-B and edges represent partial Pearson's correlations between two items given all other items in the network. In dichotomous data, Pearson's correlations are phi coefficients, which are related to a 2×2 contingency table. Phi coefficients were used because the schizotypy scales are positively skewed (Christensen et al., 2018b; Glass and Hopkins, 1970). All networks were visualized using the *qgraph* package in R.

2.4.3. Confirmatory factor analysis

To evaluate the EGA dimensions, we compared the models to the theoretical factors using CFA. The diagonally weighted least squares (WLSMV) estimator was used to compute the correlation matrices and all factors were allowed to correlate in each of the models. Each model was fit using the *lavaan* package (Rosseel, 2012) in R. We statistically compared the fit of the theoretical and EGA dimensions based on the Satorra-Bentler chi-square test (Satorra and Bentler, 2010) and qualitatively compared the fit using the comparative fit index (CFI), standardized root mean residual (SRMR), and root mean square error of approximation (RMSEA). Good fit was determined by values of a $CFI \geq 0.95$, $SRMR \leq 0.08$, and $RMSEA \leq 0.05$ (Kline, 2015).

2.5. R code and materials sharing

All R code, analytic methods, and study materials are available on the Open Science Framework for reproduction and replication purposes https://osf.io/mzn72/.

3. Results

Descriptive statistics for the theoretical and EGA dimensions for both samples of the MSS and MSS-B are reported in Table 1, Table 2, respectively.

Table 1. Descriptive statistics and correlations of theoretical and EGA factors for the MSS.

Dimensions	Positive	Disorganized	Negative	Social anhedonia	Affective anhedonia
Positive	3.72 (4.50) 3.58 (4.41)	**0.43***	0.16*	0.11*	0.18*
Disorganized	**0.48***	3.88 (5.69) 4.05 (5.81)	**0.34***	0.25*	**0.38***
Negative	0.19*	**0.34***	3.78 (4.61) 3.53 (4.36)	*0.94**	*0.73**
Social anhedonia	0.14*	0.25*	*0.94**	2.63 (3.50) 2.48 (3.32)	**0.45***
Affective anhedonia	0.20*	**0.38***	*0.73**	**0.45***	1.15 (1.82) 1.05 (1.70)

Note. Diagonal values are the mean and standard deviation (in parentheses) for Sample 1 (bottom) and Sample 2 (top). Correlations are below the diagonal for Sample 1 and above the diagonal for Sample 2. Significance of $\alpha = 0.001$ was adjusted for sample size following Pérez and Pericchi (2014); $p_{adjusted} < 0.00017$* (Sample 1) and $p_{adjusted} < 0.00045$* (Sample 2). Cohen's (1992) effect sizes of moderate (bold) and large (bold and italic) are denoted.

Table 2. Descriptive statistics and correlations of theoretical and EGA factors for the MSS-B.

Dimensions	Positive	Disorganized	Negative	Social anhedonia	Affective anhedonia
Positive	1.93 (2.34) 1.85 (2.34)	**0.39***	0.13*	0.08	0.17*
Disorganized	**0.43***	1.73 (2.85) 1.82 (2.89)	**0.32***	0.23*	**0.36***
Negative	0.17*	**0.32***	1.85 (2.47) 1.76 (2.35)	*0.92**	*0.76**
Social Anhedonia	0.12*	0.23*	*0.91**	1.24 (1.80) 1.20 (1.71)	**0.44***
Affective Anhedonia	0.18*	**0.34***	*0.75**	**0.42***	0.62 (1.08) 0.56 (1.04)

Note. Diagonal values are the mean and standard deviation (in parentheses) for Sample 1 (bottom) and Sample 2 (top). Correlations are below the diagonal for Sample 1 and above the diagonal for Sample 2. Significance of $\alpha = 0.001$ was adjusted for sample size following Pérez and Pericchi (2014); $p_{adjusted} < 0.00017$* (Sample 1) and $p_{adjusted} < 0.00045$* (Sample 2). Cohen's (1992) effect sizes of moderate (bold) and large (bold and italic) are denoted.

3.1. MSS dimensions

EGA was conducted to examine the factor structure underlying the MSS. The EGA analyses revealed four dimensions in the MSS for both samples—positive schizotypy, two dimensions of

negative schizotypy (affective and social anhedonia) and disorganized schizotypy.[1] The positive and negative schizotypy dimensions were largely disconnected (i.e., had few connections between items in their dimensions) in both samples (Fig. 1). Notably, the item content of all four dimensions was identical in both samples (Fig. 1). Next, we conducted CFA analyses to examine the fit of two models: the three-factor theoretical model and the four-factor EGA model. In the three-factor model, the items were designated based on the scales' definition (26 items each for the positive and negative factors and 25 items for the disorganized factor; Appendix A). In the four-factor model, the items were designated based on the EGA community results (26 items for the positive factor, 18 items for the negative schizotypy social anhedonia factor, 8 items for the negative schizotypy affective anhedonia factor, and 25 items for the disorganized factor).
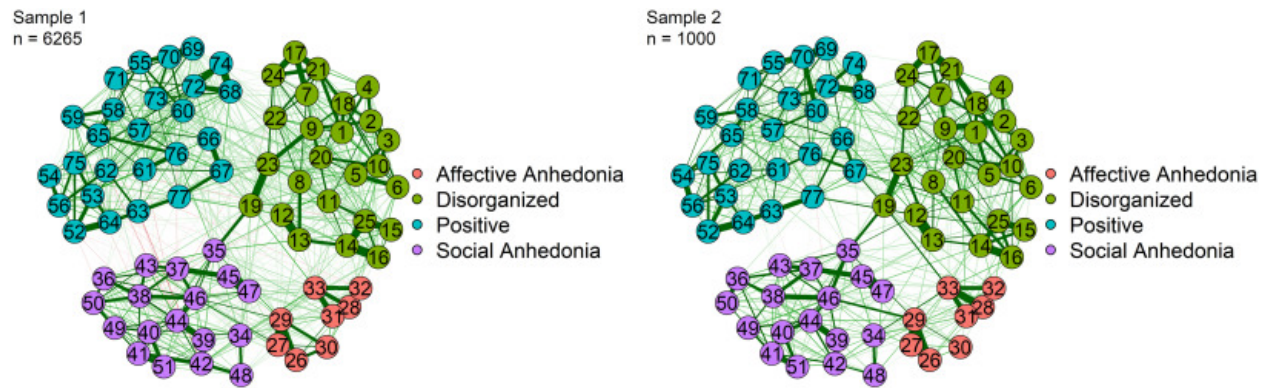

Figure 1. MSS networks displaying the EGA-identified dimensional factors.

The model fit indices for the theoretical and EGA models are reported in Table 3. In general, both the theoretical and EGA model fit well for both samples, with all indices suggesting good fit. Both EGA models suggested slightly better fit based on all indices. Indeed, the Satorra-Bentler chi-square test for model comparison revealed that the EGA model fit significantly better for Sample 1, χ^2 (3) = 70.492 and Sample 2, χ^2 (3) = 18.398 (both p's < 0.001).

Table 3. CFA model comparison of the theoretical and EGA models of the MSS and MSS-B.

Inventory	Sample	Model	Fit indices				
			Robust χ^2 (*df*)	CFI	SRMR	RMSEA	S-B χ^2 Test (*df*)
MSS	1	Theoretical	15,509.253 (2846)	0.943	0.049	0.035	70.492 (3)
		EGA	12,468.937 (2843)	0.960	0.041	0.029	
	2	Theoretical	4734.761 (2846)	0.936	0.060	0.035	18.398 (3)
		EGA	4247.557 (2843)	0.959	0.054	0.028	
MSS-B	1	3-Factor (both)	5595.745 (662)	0.937	0.049	0.037	98.725 (3)
		4-Factor	4628.979 (659)	0.953	0.043	0.032	
	2	3-Factor (both)	1533.000 (662)	0.924	0.061	0.039	20.232 (3)
		4-Factor	1361.852 (659)	0.946	0.055	0.033	

Note. MSS, Multidimensional Schizotypy Scale; MSS-B, Multidimensional Schizotypy Scale-Brief; CFI, comparative fit index; SRMR, standardized root mean square residual; RMSEA, root mean square error of approximation. All p's < 0.001 for Satorra-Bentler (S—B) χ^2 tests.

3.2. MSS-B dimensions

EGA was also conducted to uncover the underlying dimensions of the MSS-B. The EGA results found three dimensions—positive (13 items), negative (13 items), disorganized (12 items)

schizotypy—in both samples, consistent with the theoretically-defined factors of the MSS-B (Fig. 2; Appendix B).[2] Similar to the depiction of the MSS, the positive and negative schizotypy dimensions appeared to be largely disconnected (Fig. 2). Considering the theoretical and EGA results were identical to the theoretically-defined factors, the CFA analyses were computed for the same model.
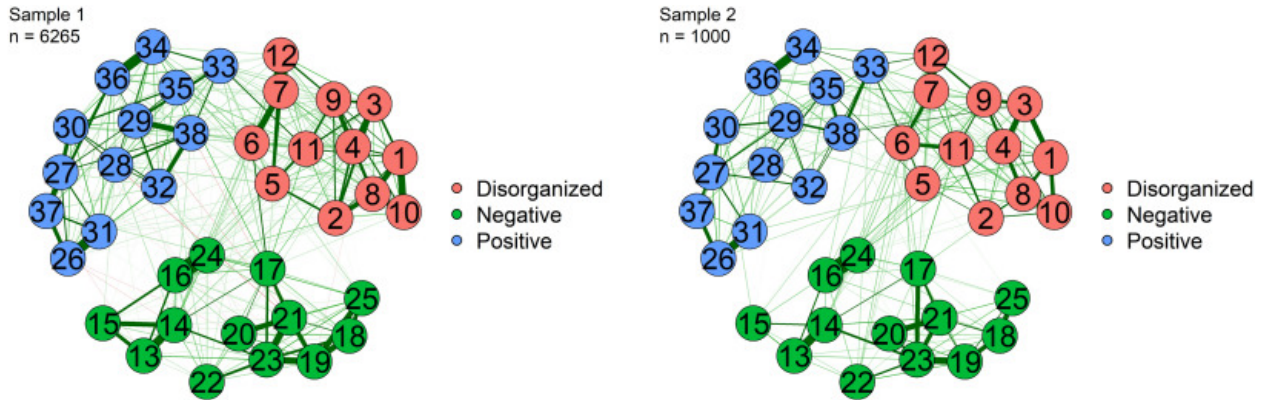

Figure 2. MSS-B networks displaying the EGA-identified dimensional factors.

For a comparison model, items in the MSS-B that were designated as a part of the affective (five items) and social anhedonia (eight items) dimensions of negative schizotypy in the MSS were used to form a comparable four-factor model. We used the same fit indices as the MSS. The model fit indices for the three-factor and four-factor models are reported in Table 3. Like the MSS, both models provided good fit and the four-factor model fit slightly better for all fit indices than the three-factor in both samples. Similar to the MSS, the Satorra-Bentler chi-square test for model comparison found that the four-factor model fit significantly better for Sample 1, $\chi^2(3) = 98.725$, and Sample 2, $\chi^2(3) = 20.232$ (both p's < 0.001).

3.3. MSS and MSS-B dimensional correlations

Summed totals of each participant's responses were used to estimate correlations between the theoretical and EGA dimensions for both the MSS and MSS-B. Note that the only difference in these dimensions was whether the negative schizotypy dimension was one (theoretical) or two (EGA) dimensions. Table 1 reports the correlations for both samples of the MSS. For all correlation analyses, we used an $\alpha = 0.001$ that was adjusted by sample size based on Pérez and Pericchi (2014). The adjusted p-value holds the level of desired significance constant across sample sizes, allowing for greater statistical consistency. Cohen's (1992) effect sizes are reported for all correlations in Table 1, Table 2.

All effect sizes were comparable between the two samples. In both samples, the social anhedonia and affective anhedonia dimensions were positively correlated, with a moderate effect size. In addition, the two dimensions had comparable relations to the positive schizotypy dimensions, while affective anhedonia had a larger effect size with the disorganized dimension than social anhedonia in both samples. Based on the depiction of the MSS networks (Fig. 1), we also computed partial correlations for the positive, negative, and disorganized dimensions to examine if positive and negative schizotypy were still correlated after controlling for the disorganized dimension. For both samples of the MSS, the positive and negative schizotypy dimensions were

no longer significantly related after controlling for the disorganized dimension (Sample 1, $r = 0.03$, $p = .019$; Sample 2, $r = 0.01$; $p = .667$).

Table 2 reports the correlations for both samples of the MSS-B. Note that the affective and social anhedonia dimensions were found using the EGA results from the MSS, and were subsequently applied to the MSS-B. Similar to the MSS, the effect sizes were closely comparable between the two samples. Social anhedonia and affective anhedonia were positively correlated with a moderate effect size in both samples. Again, affective anhedonia had a larger effect size with the disorganized dimension than social anhedonia in both samples. Based on the depiction of the MSS-B networks (Fig. 2), we computed partial correlations between positive, negative and disorganized schizotypy to determine if the relationship between positive and negative schizotypy was still significant. Neither Sample 1 ($r = 0.04$, $p = .002$) nor Sample 2 ($r = 0.01$, $p = .876$) produced significant correlations for positive and negative schizotypy when controlling for the disorganized schizotypy dimension.

4. Discussion

This was the first study to test the validity of the theoretical three-factor structure of the MSS and MSS-B, and the first to apply EGA to any measure of schizotypy. We compared the theoretical dimensions—positive, negative, and disorganized schizotypy—with those identified by EGA and our results demonstrate that EGA possesses some advantages over traditional approaches. First, EGA's deterministic dimensional structure produced models that fit at least as well as the theoretically defined structure. Second, the graphical representation of the dimensions provided insight into how these dimensions were related to one another, suggesting that the positive and negative dimension of the MSS and MSS-B were largely independent.

4.1. Dimensional structure of the MSS and MSS-B

EGA's results revealed four dimensions in the MSS—positive schizotypy, two dimensions of negative schizotypy (affective and social anhedonia), and disorganized schizotypy—and three dimensions in the MSS-B, which were consistent with the theoretical dimensions. The fit indices of the CFA models suggested that the four-factor model fit better in both scales, although the fit was good for all models. Overall, these findings suggest that there are possibly four dimensions that underlie the MSS and MSS-B, with two dimensions—affective anhedonia and social anhedonia—underlying the negative schizotypy factor.

The present findings provide useful directions for further studies of schizotypy and examinations of the validity of the MSS and MSS-B. First, the results provide further support for the multidimensional structure of schizotypy and for these two new questionnaire measures. Our findings were consistent with the three-dimensional model found in the Schizotypy Personality Questionnaire (SPQ; Fonseca-Pedrero et al., 2018a; Raine, 1991) and corroborate previous evidence provided by a network analysis of the SPQ's subscales, which found three clusters relating to positive, negative, and disorganized schizotypy (Fonseca-Pedrero et al., 2018b). Furthermore, the items of the MSS and MSS-B loaded onto their expected factors. Separate facets within negative schizotypy was not intended by the scale developers but fits with the two major components of negative schizophrenia-spectrum symptoms (diminished affect and social

disinterest). Future studies should examine the extent to which these facets separately enhance our identification of schizotypy and whether these facets have differential patterns of associations with symptoms and impairment.

We found that positive and negative schizotypy factors appeared to be largely independent of one another. This is consistent with previous CFA studies using the Wisconsin Schizotypy Scales (e.g., Kwapil et al., 2008). Although not explicitly tested, we propose that disorganized schizotypy may mediate the relationship between positive and negative schizotypy. This notion seems to be supported by the partial correlation findings, which showed that the positive and negative schizotypy dimensions were no longer related when controlling for the disorganized dimension. This interpretation is consistent with the contention by Flückiger et al. (2016) that disorganized schizotypy presents as a higher order factor that predicts the other two schizotypy dimensions.

Disorganized schizotypy primarily involves disruptions in the ability to organize and execute thoughts, speech, and behavior. Thus, it is not entirely surprising that the dimension is associated with positive and negative schizotypy, given that the latter dimensions can involve disturbances in cognition (typically content of thought in positive schizotypy and diminished thought in negative schizotypy) and disrupted behavior (typically in terms of eccentric behavior driven by positive symptoms or withdrawn behavior in negative schizotypy). Furthermore, the possible mediating role of disorganized schizotypy is consistent with historical models that cognitive slippage underlies other schizotypic symptoms (Meehl, 1962) and that splitting of associative threads underlies psychotic and deficit symptoms of schizophrenia (Bleuler, 1950). In addition, this finding aligns with current models suggesting that cognitive-behavioral disturbances play a central role in the development of psychotic-like symptoms and psychosis (e.g., Debbané et al., 2015) and findings that disorganized schizotypy mediated the relationship between negative and positive schizotypy in a three-year follow-up study (Debbané et al., 2013). Future studies should examine the extent to which disorganized schizotypy mediates and moderates the association and expression of positive and negative schizotypy.

Finally, an important question is whether the schizotypy dimensions measured by the MSS and MSS-B reflect latent liability for developing symptoms of schizophrenia-spectrum disorders (Thomas et al., 2018). Factor analytic findings of positive and negative syndromes suggest that these symptom groups are independent of one another (Lenzenweger and Dworkin, 1996; Liddle, 1987). In addition, the disorganization syndrome consisted of symptoms that were once classified as a part of positive and negative symptom groups (Liddle, 1987). Thus, our study found evidence that the theoretical and observed dimensional structure of the MSS and MSS-B aligns with diagnostic factors of schizophrenia-spectrum disorders. Future research is necessary, however, to determine whether these dimensional structures demonstrate diagnostic-relevant liability for the development of these disorders.

4.2. Implications of Exploratory Graph Analysis

In general, we found support for EGA as a robust method for determining the dimensional structure of the MSS and MSS-B. Our study contributes to the emerging literature that demonstrates EGA can produce dimensional results that are comparable to theory (Golino and

Demetriou, 2017; Golino and Epskamp, 2017; Golino et al., 2018). It's worth noting, however, that all models fit well, thus we do not suggest that the dimensions identified by EGA and the theoretical dimensions are incompatible. Instead, we suggest that the EGA dimensions provide evidence for the construct validity of the theoretical dimensions and present a more nuanced interpretation of the negative schizotypy factor in the MSS. Notably, EGA discovered dimensions that were identical to the theoretical dimensions of the MSS-B. An advantage of EGA was that these dimensions were discovered without a priori direction and were interpreted without having to decipher the item content of each dimension. In addition, these results provide a more detailed representation of how items within these dimensions are related and how the dimensions are situated in multidimensional space to one another. Our results, for example, provided graphical evidence for the potential of disorganized schizotypy to mediate positive and negative schizotypy.

4.3. Limitations

There are, however, several limitations in our study. One limitation is that our study used self-report data only. Because of this, our interpretation of disorganized schizotypy mediating positive and negative schizotypy does not immediately generalize to behavioral and clinical expressions of schizophrenia-spectrum disorders. Thus, more research is necessary to investigate whether behavioral expressions of cognitive deficits (e.g., episodic memory; Sahakyan and Kwapil, in press) mediate the relationship between positive and negative schizotypy factors and schizophrenia-spectrum symptoms. Another limitation is the detection of item dimensionality in EGA. Although EGA deterministically decides the number of dimensions and their item content, this does not mean that its decisions are absolute or infallible. Indeed, researchers should always carefully consider the item content of dimensions through a theoretical lens. Notably, EGA is relatively new and still developing; therefore, future research should attempt to tackle this issue.

4.4. Conclusion

We found support for a three- and four-dimensional model underlying the MSS and MSS-B. EGA's four dimensions complement the three theoretical factors that were initially intended for the scales. In addition, this study contributes to growing evidence that EGA is a useful tool for estimating and examining the dimensions of a construct. Our research provides a future avenue for schizotypy researchers who use the MSS and MSS-B to examine the possibility of the mediating role of disorganized schizotypy and the separate but related dimensions of negative schizotypy and their implications for divergent discriminant validity.

Appendix A. Multidimensional Schizotypy Scales key

Node #	MSS dimension	EGA dimension	Item description
1	Disorganized	Disorganized	Most of the time I find it is very difficult to get my thoughts in order.
2	Disorganized	Disorganized	No matter how hard I try, I can't organize my thoughts.
3	Disorganized	Disorganized	Even when I have time, it is almost impossible to organize my thoughts.
4	Disorganized	Disorganized	Most of the time my thoughts seem clear and organized.
5	Disorganized	Disorganized	My thoughts are so hazy and unclear that I wish that I could just reach up and put them into place.

Node #	MSS dimension	EGA dimension	Item description
6	Disorganized	Disorganized	My thoughts almost always seem fuzzy and hazy.
7	Disorganized	Disorganized	Things slip my mind so often that it's hard to get things done.
8	Disorganized	Disorganized	I have a hard time staying on topic while speaking.
9	Disorganized	Disorganized	My thoughts often feel so jumbled that I have difficulty doing anything.
10	Disorganized	Disorganized	My thoughts are almost always hard to follow.
11	Disorganized	Disorganized	I find that I am very often confused about what is going on around me.
12	Disorganized	Disorganized	I often find that when I talk to people I don't make any sense to them.
13	Disorganized	Disorganized	People find my conversations to be confusing or hard to follow.
14	Disorganized	Disorganized	I have trouble following conversations with others.
15	Disorganized	Disorganized	When people ask me a question, I often don't understand what they are asking.
16	Disorganized	Disorganized	It is usually easy for me to follow conversations.
17	Disorganized	Disorganized	My lack of organization often makes it hard to do the things that I am supposed to do.
18	Disorganized	Disorganized	My thoughts and behaviors are almost always disorganized.
19	Disorganized	Disorganized	I often feel so disconnected from the world that I am not able to do things.
20	Disorganized	Disorganized	My thoughts and behaviors feel random and unfocused.
21	Disorganized	Disorganized	I often have difficulty organizing what I am supposed to be doing.
22	Disorganized	Disorganized	When I try to do one thing, I often become confused and start doing something else.
23	Disorganized	Disorganized	I often feel so mixed up that I have difficulty functioning.
24	Disorganized	Disorganized	I often struggle to stay organized enough to complete simple tasks throughout the day.
25	Disorganized	Disorganized	I often have difficulty following what someone is saying to me.
26	Negative	Affective	Throughout my life I have noticed that I rarely feel strong positive or negative emotions.
27	Negative	Affective	I rarely feel strong emotions even in situations in which other people usually do.
28	Negative	Affective	Throughout my life there have been very few things that interest me.
29	Negative	Affective	My emotions have almost always seemed flat regardless of what is going on around me.
30	Negative	Affective	Generally, I do not have many thoughts or emotions.
31	Negative	Social	I often look forward to upcoming events.
32	Negative	Affective	Throughout my life, very few things have been exciting or interesting to me.
33	Negative	Affective	I tend to have few interests.
34	Negative	Social	In general, I have always preferred to be disconnected from the world.
35	Negative	Social	Having close friends is not as important as people say.
36	Negative	Social	I have never really been interested in having close relationships.
37	Negative	Social	In general, it is important for me to have close relationships with other people.
38	Negative	Social	When I move to a new place, I feel a strong desire to make friends.
39	Negative	Social	If given the choice, I would much rather be with another person than alone.

Node #	MSS dimension	EGA dimension	Item description
40	Negative	Social	Although there are things I enjoy doing by myself, I usually have more fun when I do things with…
41	Negative	Social	I enjoy meeting new people and making new friends.
42	Negative	Social	It has never been important to me to be involved with other people.
43	Negative	Social	Most of the time I feel a desire to be connected with other people.
44	Negative	Social	Throughout my life, I have had little interest in dating or being in a romantic relationship.
45	Negative	Social	I generally am not interested in being emotionally close with others.
46	Negative	Affective	There are just are not many things that I have ever really enjoyed doing.
47	Negative	Social	I have little or no interest in sex or romantic relationships.
48	Negative	Social	I greatly enjoy traveling to new places.
49	Negative	Social	Just being with other people can make me feel good.
50	Negative	Social	Spending time with close friends and family is important to me.
51	Negative	Social	Having a meal with other people is almost always better than eating alone.
52	Positive	Positive	I believe that dreams have magical properties.
53	Positive	Positive	I believe that ghosts or spirits can influence my life.
54	Positive	Positive	I believe that I could read other peoples' minds if I really tried.
55	Positive	Positive	I have had the momentary feeling that I might not be human.
56	Positive	Positive	Some people can make me aware of them just by thinking about me.
57	Positive	Positive	I have had the momentary feeling that someone's place has been taken by a look-alike.
58	Positive	Positive	I often wonder if everyone in the world is part of a secret experiment.
59	Positive	Positive	I have worried that people on other planets may be influencing what happens on Earth.
60	Positive	Positive	I occasionally have the feeling that my thoughts are not my own.
61	Positive	Positive	I have sometimes felt that strangers were reading my mind.
62	Positive	Positive	I have felt that there were messages for me in the way things were arranged, like furniture in a…
63	Positive	Positive	Sometimes I feel that a television show or movie has a special message just for me.
64	Positive	Positive	I believe that there are secret signs in the world if you just know how to look for them.
65	Positive	Positive	I sometimes wonder if there is a small group of people who can control everyone else's behavior.
66	Positive	Positive	I occasionally worry that people I see on the street are spying on me.
67	Positive	Positive	I often worry that other people are out to get me.
68	Positive	Positive	I often think that I hear people talking only to discover that there was no one there.
69	Positive	Positive	Occasionally I have felt as though my body did not exist.
70	Positive	Positive	At times I have wondered if my body was really my own.
71	Positive	Positive	I have felt that something outside my body was a part of my body.
72	Positive	Positive	There are times when it feels like someone is touching me when no one is actually there.

Node #	MSS dimension	EGA dimension	Item description
73	Positive	Positive	Sometimes when I look at ordinary objects they seem strange or unreal.
74	Positive	Positive	There are times when I think I see another person, but there is actually no one there.
75	Positive	Positive	I have had experiences with seeing the future, ESP or a sixth sense.
76	Positive	Positive	I often worry that someone or something is controlling my behavior.
77	Positive	Positive	I often find hidden meanings or threats in things that people say or do.

Note. Social anhedonia (Social) and affective anhedonia (Affective) facets combined are the negative schizotypy factor.

Appendix B. Multidimensional Schizotypy Scales-Brief key

Node #	MSS dimension	EGA dimension	Item description
1	Disorganized	Disorganized	Most of the time I find it is very difficult to get my thoughts in order.
2	Disorganized	Disorganized	No matter how hard I try, I can't organize my thoughts.
3	Disorganized	Disorganized	My thoughts are so hazy and unclear that I wish that I could just reach up and put them into place.
4	Disorganized	Disorganized	My thoughts are almost always hard to follow.
5	Disorganized	Disorganized	I find that I am very often confused about what is going on around me.
6	Disorganized	Disorganized	People find my conversations to be confusing or hard to follow.
7	Disorganized	Disorganized	I have trouble following conversations with others.
8	Disorganized	Disorganized	My thoughts and behaviors are almost always disorganized.
9	Disorganized	Disorganized	My thoughts and behaviors feel random and unfocused.
10	Disorganized	Disorganized	I often have difficulty organizing what I am supposed to be doing.
11	Disorganized	Disorganized	I often feel so mixed up that I have difficulty functioning.
12	Disorganized	Disorganized	I often have difficulty following what someone is saying to me.
13	Negative	Affective	Throughout my life I have noticed that I rarely feel strong positive or negative emotions.
14	Negative	Affective	My emotions have almost always seemed flat regardless of what is going on around me.
15	Negative	Affective	Generally, I do not have many thoughts or emotions.
16	Negative	Affective	Throughout my life, very few things have been exciting or interesting to me.
17	Negative	Social	In general, I have always preferred to be disconnected from the world.
18	Negative	Social	Having close friends is not as important as people say.
19	Negative	Social	In general, it is important for me to have close relationships with other people.
20	Negative	Social	If given the choice, I would much rather be with another person than alone.
21	Negative	Social	Most of the time I feel a desire to be connected with other people.
22	Negative	Social	Throughout my life, I have had little interest in dating or being in a romantic relationship.
23	Negative	Social	I generally am not interested in being emotionally close with others.
24	Negative	Affective	There are just are not many things that I have ever really enjoyed doing.
25	Negative	Social	Spending time with close friends and family is important to me.
26	Positive	Positive	I believe that dreams have magical properties.

Node #	MSS dimension	EGA dimension	Item description
27	Positive	Positive	Some people can make me aware of them just by thinking about me.
28	Positive	Positive	I have had the momentary feeling that someone's place has been taken by a look-alike.
29	Positive	Positive	I have sometimes felt that strangers were reading my mind.
30	Positive	Positive	I have felt that there were messages for me in the way things were arranged, like furniture in a…
31	Positive	Positive	I believe that there are secret signs in the world if you just know how to look for them.
32	Positive	Positive	I sometimes wonder if there is a small group of people who can control everyone else's behavior.
33	Positive	Positive	I often worry that other people are out to get me.
34	Positive	Positive	I often think that I hear people talking only to discover that there was no one there.
35	Positive	Positive	At times I have wondered if my body was really my own.
36	Positive	Positive	There are times when it feels like someone is touching me when no one is actually there.
37	Positive	Positive	I have had experiences with seeing the future, ESP or a sixth sense.
38	Positive	Positive	I often worry that someone or something is controlling my behavior.

Note. Social anhedonia (Social) and affective anhedonia (Affective) facets combined are the negative schizotypy factor.

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