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Trait schizotypy and the psychosis prodrome: Current standard assessment of extended psychosis spectrum phenotypes

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ABSTRACT

Schizotypy has become an increasingly important construct for elaborating psychotic disorders that vary along the schizophrenic spectrum. However, different schizotypy inventories vary in conceptual approach and measurement. In addition, commonly used schizotypy scales have been seen as qualitatively different from screening instruments for prodromal schizophrenia like the Prodromal Questionnaire-16 (PQ-16).

Our study investigated the psychometric properties of three schizotypy questionnaires (the Schizotypal Personality Questionnaire–Brief, Oxford-Liverpool Inventory of Feelings and Experiences, and the Multidimensional Schizotypy Scale) as well as the PQ-16 in a cohort of 383 non-clinical subjects. We initially evaluated their factor structure using Principal Component Analysis (PCA) and used Confirmatory Factor Analysis (CFA) to test a newly proposed composition of factors.

PCA results support a three-factor structure of schizotypy that accounts for 71 % of the total variance, but also shows cross-loadings of some schizotypy subscales. CFA of the newly composed schizotypy factors (together with an added neuroticism factor) shows good fit. Analyses including the PQ-16 indicate considerable overlap with measures of trait schizotypy, suggesting that the PQ-16 might not be quantitatively or qualitatively different from schizotypy measurements.

Taken together, results indicate that there is good support for a three-factor structure of schizotypy but also that different schizotypy measurements grasp facets of schizotypy differently. This points towards the need for an integrative approach for assessing the construct of schizotypy.

1. Introduction

Schizotypy describes a phenotype capturing a broad set of schizophrenia-like trait representations and thereby illustrating vulnerability for schizophrenia-spectrum disorders, which makes the schizotypy construct increasingly important for schizophrenia research (Barrantes-Vidal et al., 2015; Mason, 2015; Nelson et al., 2013). Similar to schizophrenia, schizotypy is often conceptualized using a three-factor construct (Fonseca-Pedrero et al., 2021; Kwapil and Barrantes-Vidal, 2015; Polner et al., 2021), comprising positive, negative, and disorganized facets: Positive schizotypy includes psychotic-like experiences such as perceptual biases and odd beliefs, negative schizotypy is characterized by deficits in functioning such as flattened affect, diminished motivation, and social disinterest, and disorganized schizotypy is characterized by disruptions in the organization and expression of thought, speech, behavior, and emotions.

The construct of schizotypy is well suited to further elucidate schizophrenia-spectrum disorders (SSD) by associating schizotypy not only with clinical features of SSD but also in studies exploring genetic risk (Ettinger et al., 2014; Kemp et al., 2021; Meller et al., 2019b; Nenadić et al., 2022; Walter et al., 2016), as well as neurobiological (Ettinger et al., 2015; Kirschner et al., 2022; Meller et al., 2019a, 2020; Pfarr and Nenadić, 2020; Sahakyan et al., 2020; Tonini et al., 2021) and cognitive correlates (Carrigan and Barkus, 2017; Ettinger et al., 2015;

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Karamaouna et al., 2020; Sahakyan and Kwapil, 2016; Steffens et al., 2018).

While there is some consensus that schizotypy, like schizophrenia, should be seen as a multidimensional construct varying along a continuum of health and illness, terminology and assessment of schizotypy is still used heterogeneously (Oezgen and Grant, 2018), prompting the need for further evaluation and definition of the construct (Rivera Tapia, 2022; Grant et al., 2018; Kwapil and Barrantes-Vidal, 2015).

1.1. Delineating schizotypy

Although schizotypy is not (always) necessarily seen as a psychopathological construct itself, it is an important part of the psychosis continuum (van Os et al., 2009), which spans from non-clinical manifestations of schizotypal traits to those associated with schizophrenia spectrum pathology. This continuity is indeed described elaborately in the literature (e.g., Claridge and Beech, 1995; Grant et al., 2018; Kwapil and Barrantes-Vidal, 2015). However, within the psychosis continuum, conceptual ambiguity about the construct of schizotypy makes it difficult to define what is part of this continuum and what these parts of the continuum actually mean with regards to content (Grant et al., 2018). A unifying conceptualization of the construct of schizotypy therefore remains open.

Previous work has studied associations of schizotypy with other psychopathological dimensions separately, which is important to gain more conceptual clarity. Lewandowski et al. (2006) elaborated on associations of schizotypy with symptoms of mood and anxiety disorders, finding anxious and depressive symptoms to be highly correlated with positive psychometric schizotypy in a non-clinical sample. More recently, Kemp et al. (2018) included disorganized schizotypy and found that clinical and non-clinical manifestations of negative emotions were better accounted for by disorganized schizotypy. In another study, affective and anhedonic features were found to be correlated with negative schizotypy (Kwapil et al., 2020). Diminished affect and anxiety often result in decreased social behavior (de Lijster et al., 2018; Kupferberg et al., 2016), raising the question to which extent affective or anhedonic features as well as anxiety are part of schizotypy conceptually (or only result in similar behavioural markers) and how they should be considered when measuring psychometric schizotypy. As another example, non-mood psychotic disorders vs. SSDs show qualitatively different symptoms and can be clearly separated from each other on a categorical level but overlap on a dimensional level. As a part of the psychosis continuum, it is obvious that schizotypy should also represent these diverse facets. However, it is still unclear whether and to which amount related mood and anxiety symptoms and/or varying symptom representations within the spectrum of schizophrenic disorders should also be considered when measuring the construct of schizotypy. Recent findings (e.g., Kemp et al., 2018; Kwapil et al., 2020) suggested that mood and anxiety symptoms are most strongly associated with the disorganized schizotypy dimension, which appears to involve dysregulation of the experience of emotion, as well as disorganized thought, communication, and behavior.

Schizotypy has also been linked to other non-clinical personality concepts, e.g., the Big-Five personality traits or the PID-5 factors (Personality Inventory for DSM-5) (Cicero et al., 2019; Kemp et al., 2022). However, these associations need to be interpreted with caution: for example, distress-based wording for assessing neuroticism can indeed tap into schizotypy dimensions when those items are phrased distress-based, too (Asai et al., 2011; Oezgen and Grant, 2018). If this overlap should be considered by using items that reflect neuroticism or not, is still in debate. Note, however, that Kemp et al. (2022) found that associations of the schizotypy facets (using the Multidimensional Schizotypy Scale) with the PID-5 domains did not appear to be due to redundant items in the two measurements.

Moreover, there is some inconsistency about whether capturing psychosis proneness with certain measurements should be qualitatively considered the same as measuring schizotypy (Bang et al., 2019). Arguments have been offered that measurements aiming to screen for prodromal and psychotic syndromes are distinguishable from schizotypy measurements (e.g., Prodromal Questionnaire, PQ) (Ising et al., 2012; Loewy et al., 2005). More precisely, the PQ-16 represents a low-level screener of mostly positive psychotic-like experiences (PLE) (McDonald et al., 2019) to capture prodromal symptom representations. However, the PQ-16 does not consider the important aspect of time for determining a prodromal stage. Previous work on the relationship of schizotypy measurement and the PQ-16 found substantial correlation as well as a moderating effect of schizotypy for number of experienced PLEs (Kline et al., 2012), raising the question if the PQ-16 actually qualitatively differs from common schizotypy measurements.

In a study by Fonseca-Pedrero et al. (2016) the approach of latent profile analysis (LPA) was applied to schizotypy as well as prodromal measurements to identify different psychometric profiles of individuals with regard to schizotypy and clinical high-risk symptoms. Although the authors indeed found moderately high correlations between the PQ-16 and the positive and disorganized subscales of the included schizotypy measurements, the PQ-16 appeared to be useful to distinguish between the two classes of “high positive schizotypy” and “psychosis high risk”.

1.2. Conceptualisations of schizotypy measurements

In a comparative study Oezgen and Grant (2018) investigated and compared the outcome of three commonly used schizotypy questionnaires in one sample and showed that results indeed depend on the particular schizotypy measurement used. The variability across schizotypy measurements lies not only in range and length but also in content and factor-structure (Cohen et al., 2015; Mason, 2015). This can be mostly attributed to the fact that current schizotypy measurements were derived from different conceptualizations of the schizotypy construct and different scale development methods, which are shortly outlined in the following:

Early schizotypy measurements like the Wisconsin Schizotypy Scales (WSS) can be described as *distress-based*, aimed at capturing different schizophrenia-like symptom features (i.e., physical anhedonia, perceptual aberration, magical ideation, social anhedonia) on separate scales (Chapman et al., 1995). For scale development, the authors of the WSS closely followed the checklist of schizotypic experiences proposed by Meehl (1964), hence items in the WSS were chosen based on detailed trait specification using rationale scale development methods. Subsequent analysis showed that the underlying dimensional structure of the WSS is a two-factor (positive and negative) one, lacking a disorganized dimension (Gross et al., 2014; Kwapil et al., 2008). In order to not obfuscate, it should be noted that the WSS sometimes are referred to as the Chapman Psychosis Proneness Scales (Smith et al., 2016).

The Schizotypal Personality Questionnaire (SPQ) by Raine (1991) is another distress-based questionnaire that shows considerable overlap in latent factors with the WSS (Wuthrich and Bates, 2006). However, the SPQ is technically not a measure of schizotypy: The SPQ was developed to assess schizotypal personality disorder traits based on the nine diagnostic criteria of schizotypal personality disorder defined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R) (American Psychiatric Association, 1987). While Raine et al. (1994) argue for a three-factor solution of the SPQ, confirmatory factor analyses in other studies are still inconclusive regarding the actual underlying factor structure (Gross et al., 2014; Moussa-Tooks et al., 2021; Zhang and Brenner, 2017).

The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) (Mason et al., 1995) initially identified a four-factor structure for schizotypy based on exploratory factor analysis of a large set of schizotypy and personality items. Mason and Claridge (2006) subsequently suggested that schizotypy is limited to the first three factors, whereas Oezgen and Grant (2018) suggested a four-factorial solution when comparing the O-LIFE to the SPQ and the WSS. The authors of the O-LIFE

developed the scale in an atheoretical manner based on a wide range of scales, i.e., the Chapman's anhedonia scales (Chapman et al., 1976), Eysenck's Personality Questionnaire (EPQ) which includes neuroticism (Eysenck and Eysenck, 1975), or Claridge's Schizotypal Trait Questionnaire (STQ) which also taps on Borderline personality (Claridge and Broks, 1984). As a result, the O-LIFE also comprises several "atypical" schizotypy features.

The most recently developed schizotypy questionnaire for assessing schizotypy within the general population, the Multidimensional Schizotypy Scale (MSS) (Kwapil et al., 2018b), follows the three-factorial model of schizotypy and its subscales are designated as positive, negative and disorganized dimensions of schizotypy. The authors' assumptions were trait-based and items were then phrased to map on those, considering the multidimensional structure of schizotypy and non-distress based as well as culturally unbiased wording (Kemp et al., 2020; Kwapil et al., 2018b). Using confirmatory factor analyses, Kwapil et al. (2018a) reported that, as hypothesized, a three-factor structure provided the best fit for the items. However, Christensen et al. (2019) suggested that the negative schizotypy factor comprised two facets (affective and social anhedonia).

For a brief overview of the development of the different schizotypy scales regarding conceptualization, content, as well as their relationship to each other see Fig. 1.

1.3. Goals of the present study

Taken together, it is unlikely that the current commonly used schizotypy questionnaires actually share an identical latent structure and that the subscales of the different questionnaires can be used interchangeably. Understanding the scales' overlap and divergence as well as finding a unifying approach to assess schizotypy and its multidimensional structure are important for dealing with heterogeneity within the construct itself and further to use it as a useful framework for exploring schizophrenia-spectrum psychopathology. Detailed psychometric evaluation of the schizotypy measurements as well as the use of techniques to investigate and confirm overall dimensionality and factor structure of the construct are needed to gain further insights.

In the present study, we analyzed different schizotypy scales obtained in a young population sample of psychiatrically healthy subjects to address the questions of overlap (vs. differences) between conceptualization and psychometric features across the instruments introduced above, as well as their relation to the PQ-16 inventory, a commonly used questionnaire developed for assessing of prodromal signs within the schizotypy continuum. We hypothesize, that schizotypy measurements show psychometric results congruent to their method of development but differences among each other in psychometric properties as well as with regards to content. Given that the psychosis prodrome is conceptualized to be an expression of the schizotypy continuum and the fact that the PQ-16 is largely comprised of items assessing experiences found in positive schizotypy, we expect that the scale will exhibit substantial associations with the schizotypy questionnaires, especially measures of positive schizotypy.

2. Methods

2.1. Study cohort

We included 383 psychiatrically healthy participants (mean age = 23.97 years, SD = 4.18; 250 females, 133 males) recruited from the local community by circular emails, local and online advertisements. The study cohort overlaps with a recently analyzed cohort published in Nenadić et al. (2021). Prior to participation, individuals were screened using the screening instrument of the Structured Clinical Interview for DSM-IV (Wittchen et al., 1997) to ensure the absence of any current or former clinical psychiatric condition(s). Further exclusion criteria were: non-native German speaker and/or not of central European descent, psychotropic medication, general intellectual impairment/learning disability, defined as intelligence quotient (IQ) lower than 80 (estimated with the German Mehrfach-Wortschatz-Intelligenztest-B) (Lehrl et al., 1995) and exceedance of the PQ-16 cut-off as defined by Chen et al. (2016) (see Section 2.2.4 for further description). We did not specifically exclude participants with a first-degree relative suffering from a psychotic disorder.

Individuals gave written informed consent prior to participation and received financial compensation afterwards. Our study protocol was approved by the local Ethics Committee of the School of Medicine,

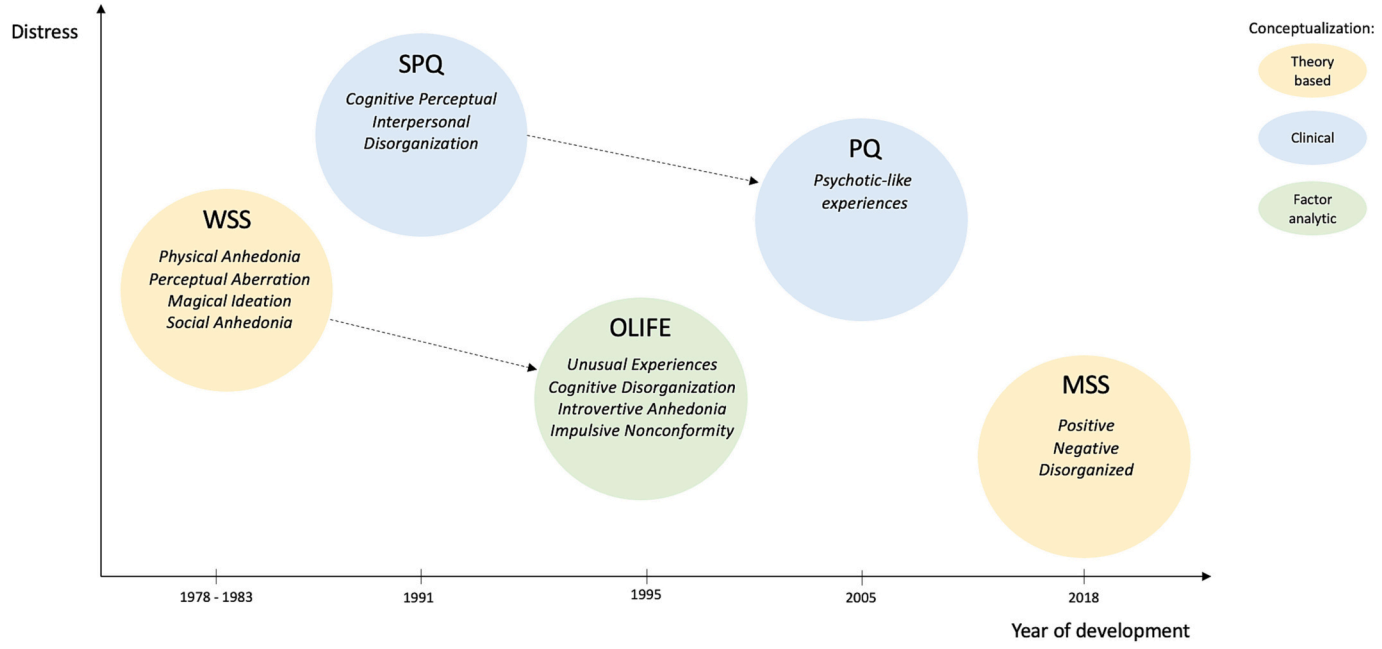

Fig. 1. Overview of different schizotypy scales.
Abbreviations: WSS=Wisconsin Schizotypy Scales, SPQ = Schizotypal Personality Questionnaire, OLIFE = Oxford-Liverpool Inventory of Feelings and Experiences, PQ = Prodromal Questionnaire, MSS = Multidimensional Schizotypy Scale.

Philipps-University Marburg (protocols no. 61/18 and 79/18), according to the latest version of the Declaration of Helsinki (World Medical Association, 2013).

2.2. Psychometric schizotypy self-report measurements

Participants received a personalized link to an online-survey platform (https://www.soscisurvey.de/; Leiner, 2019) to complete the schizotypy questionnaires within a larger test battery. All participants included in analyses had fully completed questionnaires.

Following the original validation studies (Compton et al., 2007; Kwapil et al., 2018b; Mason et al., 1995; Mason and Claridge, 2006), we calculated the subscores and sumscores of all questionnaires used, leading to a total of 13 (sub)scales for analyses. Given that our emphasis was on the dimensional structure of schizotypy, we focused our analyses on the dimensional subscales rather than total schizotypy scores. All questionnaires were administered in their German versions which were already used in previous studies (SPQ—B: (Klein et al., 1997), O-LIFE: (Grant et al., 2013), MSS: (Pfarr and Nenadić, 2020; Nenadić et al., 2021), PQ-16: (Evermann et al., 2021), BDI: (Kammer, 1983)).

2.2.1. Schizotypal Personality Questionnaire-Brief (SPQ—B)

Based on 22 yes/no-items the SPQ-B measures schizotypy on three subscales, namely the 8-item *Cognitive-Perceptual (SPQB-CP)* subscale, which taps positive schizotypy, 8-item *Interpersonal (SPQB-IP)* subscale that taps aspects of negative schizotypy, along with social anxiety and disocomfort, and the 6-item *Disorganized (SPQB-DO)* subscale that taps eccentricity (Raine, 2001). Items responded to with "yes" score 1, whereas items responded to with "no" score 0 (possible total range 0–22). Higher scores indicate higher levels of psychometric schizotypy.

2.2.2. Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE)

The O-LIFE comprises four subscales with 104 yes/no-items in total: *Unusual Experiences (UnEx), Cognitive Disorganization (CogDis), Introvertive Anhedonia (IntAn), Impulsive Nonconformity (ImpNon)* (Grant et al., 2013; Mason and Claridge, 2006). UnEx aims to tap the positive schizotypy dimension with 30 items, CogDis refers to the disorganized dimension of schizotypy although the subscale contains 24 items that assess a mix of experiences including difficulty in thinking, anxiety, and moodiness. IntAn represents the negative schizotypy dimension distributed over 27 items largely assessing physical and social anhedonia, and ImpNon captures an anti-social and eccentric form of behavior with 23 items. Items affirmatively endorsed score 1 and scoring of inversed phrased items was reversed for calculations (possible total range 0–104). Higher scores indicate higher levels of psychometric schizotypy.

2.2.3. Multidimensional Schizotypy Scale (MSS)

The MSS uses 77 true/false-items to measure schizotypy on three subscales, named according to which schizotypy dimension they capture: *MSS-Negative* with 26 items, *MSS-Positive* with 26 items as well as *MSS-Disorganized* with 25 items (Kwapil et al., 2018b). Positively endorsed items scoring 1 and negatively endorsed items scoring 0. Scoring of inversed phrased items was reversed for calculations (possible total range 0–77). Higher scores indicate higher levels of psychometric schizotypy.

2.2.4. Prodromal Questionnaire (PQ-16)

The short version of the Prodromal Questionnaire (Loewy et al., 2005) measures psychotic-like experiences (PLEs) with 16 true/false-items on a single scale (Ising et al., 2012), with positively endorsed items scoring 1 and negatively endorsed items scoring 0 (possible total range 0–16). Answers are then summed up to a PLE total score as well as a PLE distress score which indicates current distress severity by PLEs ("none" = 0 to "severe" = 3).

Chen et al. (2016) used this short version of the PQ-16 in a comparable sample to ours and concluded that individuals exceeding cut-off scores indicate the necessity of further psychopathological evaluation. We used these cut-offs in our sample and did not include individuals exceeding these thresholds in our analyses. Thus, no individuals in our sample were help-seeking and/or at elevated risk.

2.2.5. Beck Depression-Inventory (BDI)

Negative symptoms of schizotypy share some phenomenological similarities with depressive symptomatology, but can be different in both quantity as well as quality (Lewandowski et al., 2006). Hence, the two constructs should be administered separately but compared. To ensure an elaborated evaluation of the actual schizotypal characteristics of our sample, subjects completed the BDI (Beck et al., 1987) additional to the schizotypy measurements. With 21 items the depressive state of the past week is assessed. Scoring is based on declaration of current presence of symptoms (0 = symptom was not experienced during the past week; 3 = symptom was experienced predominantly during the past week). Higher scores indicate a higher level of current depressive state.

2.3. Analyses

We first computed descriptive statistics on the subscales as well as the correlation matrix. As the OLIFE_ImpNon subscale conceptually captures anti-social and impulsive/eccentric behavior rather than schizotypy (Cochrane et al., 2010) and showed very little correlation with all other scales in our analyses, this subscale was excluded from further analyses.

Second, we performed multiple Principal Component Analyses (PCAs) including the subscales of the schizotypy measurements as well as the PQ-16 in two of the PCAs, to extract the most important independent factors. PCA reduces dimensionality of a dataset by deriving a smaller number of variables (principal components) from a higher number of original variables while maintaining most of their variability (Jolliffe, 2005).We conducted three PCAs in total with the following specifications: 1. PCA: all subscales included, free factor solution; 2. PCA: all subscales included, forced three-factor solution; 3. PCA: PQ-16 excluded, forced three-factor solution.

Lastly, Confirmatory Factor Analyses (CFAs) were run to test our hypotheses regarding factor-structure of newly composed schizotypy factors. Specifically, we compared 1, 2, and 3-factor models of the schizotypy dimensions, as well as a 4-factor model with a separate neuroticism factor. The CFA analyses were differentiated from the PCA analyses by testing specific hypotheses and the use of item parcels. In order to produce robust estimates and following Kwapil et al. (2008), we computed item parcels out of the subscales which resulted in multiple parcels for positive, negative, and disorganized schizotypy, as well as neuroticism (see Little et al., 2002). Each parcel was constructed to have a comparable proportion of items from the beginning, middle, and end of the relevant subscale. Items that did not fit for content or had no variance were dropped. Discussion of our CFA approach can be found in the supplements S1 and the exact composition of the parcels as well as the dropped-out items are shown in supplementary Table S2. We hypothesized that the 3-factor model would have the best fit for the CFA analyses that only included the schizotypy parcels, and that the 4-factor model would have the best fit for the CFA analyses that included the neuroticism parcels.

3. Results

Table 1 shows the descriptive statistics and Cronbach's α of all (sub) scales used in this study, Table 2 shows their correlation coefficients. Besides SPQ subscales (Cronbach's α = 0.36/0.68) and the PQ16 (Cronbach's α = 0.62) all other measurements show good reliability (Cronbach's α = ≥0.74).

The first PCA with a free-factor solution across the MSS (with its three subscales), the SPQB (with its three subscales), the OLIFE (with

Table 1
Descriptive statistics and Cronbach's a of all scales used in this study in $N = 383$ subjects.

Scale	Mean	SD	Range	Possible Range	Coefficient Alpha	Kurtosis	Std. Err.	Skew	Std. Err.
Beck Depression Inventory	3.67	3.98	0–26	0–63	0.79	1.65	0.12	3.82	0.25
Multidimensional Schizotypy Scale	4.20	4.25	0–28	0–77	0.82	1.94	0.12	4.93	0.25
Positive Schizotypy	0.58	1.38	0–10	0–26	0.74	3.83	0.12	17.35	0.25
Negative Schizotypy	2.58	2.70	0–18	0–26	0.77	2.04	0.12	5.58	0.25
Disorganized Schizotypy	1.04	2.12	0–14	0–25	0.82	3.23	0.12	12.49	0.25
Schizotypal Personality Questionnaire	2.57	2.67	0–13	0–22	0.74	1.37	0.12	1.83	0.25
Cognitive-Perceptual	0.48	0.80	0–5	0–8	0.36	1.99	0.12	4.67	0.25
Interpersonal	1.49	1.65	0–7	0–8	0.68	1.09	0.12	0.39	0.25
Disorganized	0.60	1.11	0–6	0–6	0.68	2.33	0.12	5.77	0.25
Oxford-Liverpool Inventory of Feelings & Experiences	17.39	8.83	3–54	0–104	0.85	0.91	0.12	0.89	0.25
Unusual Experiences	1.91	2.51	0–16	0–30	0.75	2.27	0.12	6.70	0.25
Introvertive Anhedonia	4.09	3.50	0–19	0–27	0.77	1.54	0.12	2.83	0.25
Cognitive Disorganization	5.30	4.40	0–21	0–24	0.84	0.95	0.12	0.52	0.25
Impulsive Nonconformity	6.09	2.88	0–15	0–23	0.58	0.44	0.12	0.13	0.25
Prodromal Questionnaire Total	1.09	1.51	0–9	0–16	0.62	1.95	0.12	4.71	0.25
Prodromal Questionnaire Distress	1.18	1.90	0–15	0–48	0.60	2.64	0.12	10.21	0.25

three of its four subscales) and the PQ-16 total score yielded a two-factor solution (cumulative total variance explained: 60.89 %; see Table 3) with an unclear factor structure: MSS_Pos, SPQB_CP, OLIFE_UnEx and PQ16_Total load highly on factor 1 and are unrelated to factor 2. MSS_Neg, SPQB_IP, and OLIFE_IntAn load highly on factor 2 and are unrelated to factor 1. MSS_Dis, SPQB_DO, and OLIFE_CogDis cross-load on both factors with higher loadings on factor 1. Components correlate with $r = 0.32$. The second PCA with the subscales described above and a forced three-factor solution (cumulative total variance explained: 69.89 %; see Table 4) showed a more coherent factor structure: MSS_Pos, SPQB_CP, OLIFE_UnEx, and PQ16_Total load highly on factor 1 and are unrelated to factor 2 and 3, except PQ16_Total with cross-loadings on factor 2. MSS_Dis and OLIFE_CogDis load highly on factor two. MSS_Neg and OLIFE_IntAn load highly on factor 3. SPQ_DO splits across the three factors, SPQB_IP cross-loads on factor 2 and 3. Correlations of the factors: $r = 0.54$ for factor 1 and 2, $r = 0.16$ for factor 1 and 3, and $r = 0.39$ for factor 2 and 3. The third PCA (excluding PQ16_Total) with a forced three-factor solution showed the most coherent factor structure (cumulative total variance explained: 70.97 %; see Table 5): MSS_Pos, SPQB_CP, and OLIFE_UnEx load highly on factor 1 and are unrelated to factor 2 and 3. MSS_Neg and OLIFE_IntAn load highly on factor 2. MSS_Dis and OLIFE_CogDis load highly on factor 3 whereas SPQB_IP cross-loads on factor 2 and 3 and SPQB_DO cross-loads on factor 3 and 1. Thus, forced three-factor solutions accounted for more variance than the two-factor solution. However, unlike the MSS and OLIFE subscales, the SPQB_IP and SPQ_DO subscales do not show good fidelity with the negative and disorganized dimensions, respectively, as they have moderate cross-loadings across multiple factors.

CFAs including the positive, negative, and disorganized parcels (see supplementary Table S2 for exact composition of all parcels) yielded the best fit for the three-factor model, with good fit indices and the parcels loading on their respective factor (CFI = 0.92, TFI = 0.91, RMSEA = 0.052, SRMR = 0.063; see Table 6 for further fit-indices as well as factor loadings and correlations of the three-factor model). CFAs including the positive, negative, disorganized, and neuroticism parcels showed the best fit for the four-factor solution with factors being a positive, negative, and disorganized schizotypy factor as well as an additional neuroticism factor (CFI = 0.90, TFI = 0.88, RMSEA = 0.059, SRMR = 0.069; see Table 7 for further fit-indices as well as correlations of the three and four-factor model).

4. Discussion

The present study aimed to analyze schizotypy phenotypes derived from commonly used inventories. Besides providing a detailed description at the subscale level, we used a PCA approach to provide refined phenotype facets of schizotypy as well as CFAs to test the fit of these refined facets in an overall model.

Results show support for a three-factor model of schizotypy with positive, negative, and disorganized schizotypy factors, as well as for a four-factor model with a separate neuroticism factor in addition to the traditional schizotypy factors. Our results add several implications to a refined assessment of an extended psychosis spectrum phenotype:

First, while intercorrelation indices among items are moderate to high we found single items with low endorsement rates even with some items not being endorsed at all. Even though low endorsement rates are expected for a sample comprising mainly individuals of high educational level and selected for lack of history for mental disorders/ treatment, the measurements should ideally be able to discriminate between a range of schizotypal experiences within the general population. The results therefore indicate that this might not be the case but that those measurements (or certain items within these) actually tap only one specific stage within the psychosis continuum but fail to map a wider range at the lower end of the continuum. Alternatively, it may reflect items that did not work well in translation from their original English. Including qualitatively similar items that range in their quantity of certain symptom representations could lead to better item-discrimination as well as item-difficulty which would make the questionnaires more suitable for detecting subtle differences in schizotypal behavior. Additionally, different response formats beyond the common dichotomous yes/no answers could help elucidate fine discriminations. On the other hand, such formats can invite participants to normalize the items and over-report schizotypal experiences, which are presumed to be relatively rare in the general population.

Second, our comparison of schizotypy scales with the PQ-16 allows us to compare these commonly used schizotypy scales with a commonly used prodrome screening questionnaire for psychosis risk. Measuring the schizophrenia prodrome and identifying individuals at risk for developing schizophrenia has become an important and legitimate step for early intervention research as well as early intervention application (Fusar-Poli et al., 2013). Our analyses of the PQ-16 showed fairly high correlations with the schizotypy scales, especially with items of the positive schizotypy subscales. A review of the PQ-16 items indicates that they are closely comparable in wording and content to items from positive schizotypy; for example the PQ-16 item, "*I have had the sense that some person or force is around me, even though I could not see anyone*", and the SPQ-B item, "*Have you ever had the sense that some person or force is around you, even though you cannot see anyone?*", or the PQ-16 item, "*My thoughts are sometimes so strong that I can almost hear them*", and the O-LIFE item, "*Are your thoughts sometimes so strong that you can almost hear them?*". However, so far, the PQ-16 has been seen as qualitatively different from schizotypy measurements (Hinterbuchinger and

Table 2
Correlation matrix for all measurements used in this study, $N = 383$.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 BDI															
2 MSS_Sum	**0.43*****														
3 MSS_Pos	0.17**	***0.51******													
4 MSS_Neg	0.22***	***0.75******	0.06												
5 MSS_Dis	**0.48*****	***0.72******	0.29***	0.20***											
6 SPQ_Sum	**0.49*****	***0.65******	**0.43*****	**0.42*****	**0.50*****										
7 SPQ_CP	0.20***	**0.33*****	**0.47*****	0.07	0.26***	***0.56******									
8 SPQ_IP	**0.47*****	***0.55******	0.21***	**0.48*****	**0.36*****	***0.84******	0.21***								
9 SPQ_DO	**0.34*****	***0.52******	**0.37*****	0.26***	**0.47*****	***0.75******	**0.33*****	**0.39*****							
10 OLIFE_Sum	***0.58******	***0.68******	**0.41*****	**0.44*****	***0.53******	***0.68******	**0.43*****	***0.57******	**0.48*****						
11 OLIFE_UnEx	**0.32*****	**0.46*****	***0.68******	0.10*	**0.35*****	**0.46*****	***0.53******	0.23***	**0.39*****	***0.64******					
12 OLIFE_IntAn	0.26***	***0.58******	0.04	***0.72******	0.22***	**0.48*****	0.09***	***0.57******	0.25***	***0.59******	0.07				
13 OLIFE_CogDis	***0.64******	**0.49*****	0.28***	0.19***	***0.56******	**0.56*****	**0.31**	***0.52******	**0.37*****	***0.82******	**0.45*****	**0.32*****			
14 OLIFE_ImpNon	0.22***	0.22***	0.20***	0.10	0.20***	0.24***	0.27***	0.07	0.28***	***0.54******	**0.32*****	0.04	0.21***		
15 PQ16_Total	**0.42*****	***0.53******	***0.55******	0.16***	***0.50******	***0.51******	**0.41*****	**0.33*****	**0.44*****	**0.58*****	***0.66******	0.14**	***0.50******	0.28***	
16 PQ16_Distress	**0.44*****	***0.53******	***0.50******	0.20***	**0.48*****	**0.48*****	**0.33*****	**0.32*****	**0.45*****	**0.58*****	***0.62******	0.16**	***0.50******	0.28***	***0.90******

Abbreviations: BDI—Becks Depression Inventory. MSS_Sum—total score of the Multidimensional Schizotypy Scale (MSS). MSS_Pos—Positive schizotypy subscale of the MSS. MSS_Neg—Negative schizotypy subscale of the MSS. MSS_Dis—Disorganized schizotypy subscale of the MSS. SPQB_Sum–total score of the Schizotypal Personality Questionnaire-Brief (SPQ—B). SPQB_CP–Cognitive Perceptual subscale of the SPQ—B. SPQB_IP–Interpersonal subscale of the SPQ—B. SPQB_DO–Disorganized subscale of the SPQ-B. OLIFE_Sum—total score of the Oxford and Liverpool Inventory of Feelings and Experiences (OLIFE). OLIFE_UnEx—Unusual experiences subscale of the OLIFE. OLIFE_CogDis—Cognitive disorganization subscale of the OLIFE. OLIFE_IntAn—Introvertive anhedonia subscale of the OLIFE. OLIFE_ImpNon—Impulsive nonconformity subscale of the OLIFE. PQ16_Total—total score of the Prodromal Questionnaire-16 (PQ16). PQ16_Distress—Distress subscore of the PQ16.
Medium effect sizes in bold, large effect sizes in bold & italics.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 3
First Principal Component Analysis (PCA): free factor solution with Promax rotation of the following scales: MSS_Pos, MSS_Neg, MSS_Dis, SPQB_CP, SPQB_IP, SPQB_DO, OLIFE_UnEx, OLIFE_CogDis, OLIFE_IntAn, and PQ-16_Total, $N = 383$. Table shows correlation coefficients for variables loaded on the three PCs extracted as well as the totals of the Eigenvalues, and the sums of variability and cumulative squared loadings in percent.

	PC1	PC2
MSS_Pos	0.829	−0.190
MSS_Neg	−0.142	0.866
MSS_Dis	0.534	0.276
SPQB_CP	0.707	−0.109
SPQB_IP	0.180	0.735
SPQB_DO	0.531	0.279
OLIFE_UnEx	0.890	−0.144
OLIFE_CogDis	−0.149	0.926
OLIFE_IntAn	0.535	0.348
PQ16_Total	0.814	0.023
Eigenvalues	4.143	1.925
Variability (%)	41.432	19.253
Cumulative (%)	41.432	60.685

Table 4
Second PCA: Forced three-factor solution with Promax rotation of the following scales: MSS_Pos, MSS_Neg, MSS_Dis, SPQB_CP, SPQB_IP, SPQB_DO, OLIFE_UnEx, OLIFE_CogDis, OLIFE_IntAn, and PQ16_Total, $N = 383$.

	PC1	PC2	PC3
MSS_Pos	0.912	−0.107	−0.013
MSS_Neg	0.060	−0.162	0.943
MSS_Dis	-,122	0.961	−0.111
SPQB_CP	0.807	−0.123	0.059
SPQB_IP	−0.027	0.395	0.583
SPQB_DO	0.244	0.456	0.142
OLIFE_UnEx	0.843	0.082	−0.049
OLIFE_CogDis	−0.031	0.849	0.018
OLIFE_IntAn	−0.031	0.849	0.018
PQ16_Total	0.532	0.423	−0.060
Eigenvalues	4.143	1.925	0.920
Variability (%)	41.432	19.253	9.202
Cumulative (%)	41.432	60.685	69.887

Table 5
Third PCA: Forced three-factor solution with Promax rotation of the following scales: MSS_Pos, MSS_Neg, MSS_Dis, SPQB_CP, SPQB_IP, SPQB_DO, OLIFE_UnEx, OLIFE_CogDis, and OLIFE_IntAn, N = 383.

	PC1	PC2	PC3
MSS_Pos	0.894	−0.021	−0.061
MSS_Neg	0.042	0.954	−0.168
MSS_Dis	−0.084	−0.129	0.949
SPQB_CP	0.799	0.032	−0.057
SPQB_IP	−0.013	0.571	0.398
SPQB_DO	0.261	0.120	0.478
OLIFE_UnEx	0.824	−0.052	0.112
OLIFE_CogDis	0.002	0.000	0.845
OLIFE_IntAn	−0.063	0.924	−0.002
Eigenvalues	3.628	1.841	0.918
Variability (%)	40.307	20.456	10.202
Cumulative (%)	40.307	60.763	70.965

Mossaheb, 2021), even though development of the original 92 item PQ originates in schizotypy as most items were adopted from the SPQ (Loewy et al., 2005). This is mainly due to its purpose to screen for the psychosis prodrome rather than measuring the trait schizotypy (Brandizzi et al., 2014; Savill et al., 2018). However, given the conceptual background of the scale (namely the close adaption from the SPQ) together with our results, the PQ-16 might actually not quantitatively or qualitatively differ from common schizotypy measurements, but the only difference being that it largely only measures one schizotypy

Table 6
Fit-indices for all models run in the first CFA as well as correlations for the three-factor model.

Fit-indices. Model	CFI	TFI	RMSEA	SRMR	AIC	BIC	AdjBIC
1 Factor	0.47	0.41	0.133	0.151	21,150	21,398	21,198
2 Factor	0.78	0.75	0.086	0.091	20,213	20,466	20,262
3 Factor	0.92	0.91	0.052	0.063	19,776	20,036	19,827

Note: Indicators of good fit: CFI, TFI > 0.90; RMSEA <0.08; SRMR <0.08; AIC, BIC, AdjBIC – lower values indicate better fit.

Pearson correlations coefficients.

	Positive Schizotypy factor	Negative Schizotypy factor	Disorganized Schizotypy factor
Positive Schizotypy factor	1	0.14	0.53
Negative Schizotypy factor	0.14	1	0.33
Disorganized Schizotypy factor	0.53	0.33	1

Table 7
Fit-indices for all models run in the second CFA as well as correlations for the four-factor model.

Fit-indices. Model	CFI	TFI	RMSEA	SRMR	AIC	BIC	AdjBIC
3 Factor	0.87	0.85	0.066	0.072	21,686	21,970	21,742
4 Factor	0.90	0.88	0.059	0.069	21,573	21,869	21,631

Note: Indicators of good fit: CFI, TFI > 0.90; RMSEA <0.08; SRMR <0.08; AIC, BIC, AdjBIC – lower values indicate better fit.

Pearson correlations coefficients.

	Positive Schizotypy factor	Negative Schizotypy factor	Disorganized Schizotypy factor	Neuroticism factor
Positive Schizotypy factor	1	0.14	0.53	0.44
Negative Schizotypy factor	0.14	1	0.33	0.38
Disorganized Schizotypy factor	0.53	0.33	1	0.66
Neuroticism factor	0.44	0.38	0.66	1

dimension, namely positive schizotypy. Furthermore, the prodrome can simply be understood as an expression of the schizotypy continuum. Looking back at early but still valid definitions of a prodrome in a clinical context, the main common feature refers to the aspect of time: prodrome is the temporal correlation of certain behaviors with illness onset (Beiser et al., 1993; Keith and Matthews, 1991; Loebel et al., 1992). Thus, to evaluate if a person is in a prodromal stage, an instrument measuring psychosis prodrome should also consider the aspect of time, i.e., for how long a person has already been experiencing subclinical psychotic symptoms (Hinterbuchinger and Mossaheb, 2021; Schultze-Lutter et al., 2015). Research on the psychosis prodrome and schizotypy has indeed shown, that schizotypy represents a (weak, but significant) predictor of psychosis (Barrantes-Vidal et al., 2013; Debbané et al., 2015) and could thus be useful as a screening for psychosis-proneness within the general population. Taken together, when using a questionnaire specifically as a screening instrument for the psychosis prodrome rather than measuring the trait schizotypy, it should also consider the time aspect (e.g., by item wording) to sharpen its specificity.

The present results indicate that the three schizotypy scales investigated in this paper tend to measure the factors of schizotypy well. PCA analyses show that the subscales aiming to measure positive schizotypy build a coherent factor. The correlations among the schizotypy factors from the CFAs are generally consistent with findings for individual scales (e.g., Kwapil et al. (2018b)).

Note that the PCA and CFA analyses used different measured indicator variables (in part because it would be redundant to run PCA and CFA on the same indicators from the same sample). The PCA used scores computed from the full scales/subscales, whereas the CFA used parcels computed from most of the items comprising these measures (items were dropped because they did not measure specific schizotypy dimensions or due to lack of variance). The PCA was a largely exploratory approach to examine the latent structure underlying the original format of these measures, whereas the CFA compares competing models of the factor structure of schizotypy not constrained by the specific measures. This approach provided both conceptual information about schizotypy and potential problematic items in these extant measures.

The correlations of the neuroticism factor with positive and disorganized schizotypy likewise is consistent with previous studies (e.g., Kwapil et al. (2018a)). The unexpected correlation of negative schizotypy with neuroticism likely reflects the inclusion of the SPQ-IP subscale items that were not specifically designed to tap negative schizotypy and tend to be saturated with neuroticism and social anxiety. The subscales that aim to measure negative or disorganized schizotypy load indeed on their predominantly factor in the PCAs, but show fairly sufficient loadings with the other factor as well. The SPQ_IP subscale, which is usually taken as the negative schizotypy facet of the SPQ, contains some items that rather tend to measure social anxiety/neuroticism (e.g., *"I feel very uncomfortable in social situations involving unfamiliar people."*), which makes those items relate more to the OLIFE_CD subscale than to the negative schizotypy factor per se. It is important to point out that Raine (1991) constructed the SPQ_IP subscale to tap 'interpersonal discomfort' rather than creating an exclusively negative schizotypy subscale. Hence, items that prompt social anxiety/neuroticism are expected for the SPQ_IP subscale but add something new to the construct of schizotypy as those symptoms are rather unspecific for schizotypy per se. This is also the case for some items of the OLIFE_CD that tap neuroticism (e.g., *"Do you often worry about things you should not have done or said?"*, *"Are you a person whose mood goes up and down easily?"*) more so than the schizotypy factor of disorganized thoughts or behavior. This is confirmed by

our CFA analyses which showed a good fit for a three-factor schizotypy model when items of SPQ_IP and OLIFE_CD that measure neuroticism/social anxiety are excluded but also showed a good fit for a four-factor model when those items were included by a separate neuroticism-factor. Hence, some items do not seem to fit into the typical schizotypy dimensions which is important to consider when using schizotypy as a unifying construct to assess an underlying vulnerability for schizophrenia-spectrum disorders. From a clinical perspective, evaluating neurotic and anxious tendencies when assessing risk-states for SSDs is plausible (Brown et al., 2008; Kemp et al., 2018; Lewandowski et al., 2006), however, when speaking of the construct of schizotypy from a psychometric standpoint, those facets should be examined independently.

Lastly, correlations with the BDI are considerably high. This can be seen as further reassurance that schizotypy is closely related to affective anomalies, especially social anhedonia (Cohen et al., 2015), as some items in the here investigated schizotypy scales are intended to measure exactly this. Consistent with Kemp et al. (2018), BDI scores appear to have their strongest associations with the disorganized dimension of schizotypy. This is also consistent with Kemp et al.'s (2021) finding that disorganized, but not positive or negative schizotypy predicted interview-assessed major depressive disorder. Interestingly, Kemp et al. (2018) further found that modest associations of negative schizotypy with the BDI were driven by items tapping diminished positive affect but not heightened negative affect.

This study has some limitations that need to be addressed. First, our study sample consisted mostly of young, psychiatrically healthy college students. While we expect that meaningful information regarding schizophrenia-spectrum psychopathology can be identified in non-clinically ascertained samples, inclusion of a larger sample that was enriched for participants with elevated levels of schizotypy would likely enhance our power to detect meaningful relationships. We did not assess random responding, which limits the reliability of the scores administered. Furthermore, Cronbach's α for the PQ-16 as well as the SPQB_CP subscale were low. This limitation warrants investigation in further studies.

5. Conclusion

Almost every current model of schizophrenia and psychosis recognizes that there is a broad continuum of clinical and subclinical expression of symptoms and impairment. Schizotypy offers a useful and unifying framework for capturing this continuum. Furthermore, schizotypy, like schizophrenia, is best conceptualized as a multidimensional construct. However, the utility of schizotypy, especially in early-detection/−intervention research, requires clear operationalization and measurement (Rivera Tapia, 2022).

With this study we contributed to this discussion by applying two different comprehensive multivariate statistical approaches to a set of well-validated schizotypy measurements (including the MSS as a relatively new scale) as well as a prodromal questionnaire. We conclude that the construct of schizotypy is psychometrically defined differently across measurements and are proposing a newly composition for revised phenotype facets.

Declaration of competing interest

All authors declare no conflict of interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.schres.2023.03.004.

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