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Deconstructing sub-clinical psychosis into latent-state and trait variables over a 30-year time span

Wulf Rössler [a,b,*], Michael P. Hengartner [a], Vladeta Ajdacic-Gross [a], Helene Haker [c], Jules Angst [a]

[a] Department of General and Social Psychiatry, Psychiatric University Hospital, University of Zurich, Zurich, Switzerland
[b] Collegium Helveticum, a Joint Research Institute between the University of Zurich & ETH Zurich, Switzerland
[c] Translational Neuromodeling Unit (TNU), Institute for Biomedical Engineering, University of Zurich & ETH Zurich, Switzerland

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ABSTRACT

Background: Our aim was to deconstruct the variance underlying the expression of sub-clinical psychosis symptoms into portions associated with latent time-dependent states and time-invariant traits.
Methods: We analyzed data of 335 subjects from the general population of Zurich, Switzerland, who had been repeatedly measured between 1979 (age 20/21) and 2008 (age 49/50). We applied two measures of sub-clinical psychosis derived from the SCL-90-R, namely schizotypal signs (STS) and schizophrenia nuclear symptoms (SNS). Variance was decomposed with latent state–trait analysis and associations with covariates were examined with generalized linear models.
Results: At ages 19/20 and 49/50, the latent states underlying STS accounted for 48% and 51% of variance, whereas for SNS those estimates were 62% and 50%. Between those age classes, however, expression of sub-clinical psychosis was strongly associated with stable traits (75% and 89% of total variance in STS and SNS, respectively, at age 27/28). Latent states underlying variance in STS and SNS were particularly related to partnership problems over almost the entire observation period. STS was additionally related to employment problems, whereas drug-use was a strong predictor of states underlying both syndromes at age 19/20. The latent trait underlying expression of STS and SNS was particularly related to low sense of mastery and self-esteem and to high depressiveness.
Conclusions: Although most psychosis symptoms are transient and episodic in nature, the variability in their expression is predominantly caused by stable traits. Those time-invariant and rather consistent effects are particularly influential around age 30, whereas the occasion-specific states appear to be particularly influential at ages 20 and 50.

1. Introduction

In the past two decades, several studies have demonstrated that the expression of a psychosis phenotype can be observed below the threshold of its clinical detection (van Os et al., 2000; Wiles et al., 2006; Rössler et al., 2007). The occurrence of psychotic symptoms in the general population can be characterized as a continuum with differing levels of severity and persistence (Rössler et al., 2013). Van Os et al. (2009) have found in their systematic review that the median prevalence is approximately 5% for sub-clinical psychosis, which is at least five-fold higher than the prevalence for diagnosed schizophrenia (Rössler et al., 2005) or three to four times higher for non-affective psychosis in the general population (Kendler et al., 1996; Perala et al., 2007).

Van Os' research group has estimated that 75–90% of those sub-clinical psychosis symptoms are transitory and disappear over time. Otherwise we could demonstrate, that sub-clinical psychosis symptoms are quite persistent over time in some individuals (Rössler et al., 2007). Thus, subclinical psychosis may as well indicate a more stable underlying psychopathology. This latter assumption is in agreement with the concept of schizotypal personality disorder, which has been defined as a stable maladaptive personality trait (American Psychiatric Association, 2000).

There are several theoretical models that describe how sub-clinical psychosis symptoms might arise and persist. Psychosis symptoms might express an underlying liability. Such an underlying liability is not restricted to psychosis symptoms and can provoke all kind of transient psychopathological symptoms (Rössler et al., 2011b). And psychosis symptoms can also be triggered by environmental influences (for instance by acute stress). Finally, those (psychosis) symptoms provoked by the social environment can interact with various other individual personality dimensions, which can alternatively ameliorate or deteriorate the clinical picture. As a result the affected subjects then either recover more quickly or develop more enduring psychopathological manifestations.

We are not aware of any study that has attempted to determine the longitudinal latent state–trait structure of sub-clinical psychosis. To date, we are still uncertain whether liability to sub-clinical psychosis represents either transient and occasion-specific states or a stable

* Corresponding author at: Department of General and Social Psychiatry, Psychiatric University Hospital, University of Zurich, Militärstrasse 8, CH-8004 Zurich, Switzerland. Tel.: +41 44 2967400; fax: +41 44 296 7409.
E-mail address: roessler@dgsp.uzh.ch (W. Rössler).

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dispositional trait. Furthermore, the particular proportions of states and trait might vary over time. Thus, this study is the first to specifically analyze the latent state–trait structure of sub-clinical psychosis within a community sample that entails a cohort of adults evaluated seven times between the ages of 20 and 50.

Our study objectives were to: i) determine the proportion of variance explained in subclinical psychosis related to latent states and trait over a 30-year time span within a community sample, and ii) identify coping strategies, personality dimensions or environmental factors, which might relate to these latent states and trait.

2. Methods

2.1. Sampling procedure

The Zurich Study comprised a cohort of 4547 subjects (m = 2201; f = 2346) representative of the canton of Zurich in Switzerland, who were screened in 1978 with the Symptom Checklist 90 Revised (SCL-90-R) (Derogatis, 1977) when males were 19 and females were 20 years old. A stratified subsample of those participants was selected for comprehensive face-to-face interviews and subsequent follow-ups. Such a two-phase procedure is fairly common in epidemiological research (Dunn et al., 1999) and is applied to enrich the interview sample with persons at risk for psychopathological syndromes. Stratification was based on a cut-off value along the 85th percentile of the SCL-90-R global severity index (GSI). Two-thirds of the interview cohort comprised high scorers (defined by the 85th percentile or above on the GSI) while the remaining third was randomly selected from the rest of the initial sample (GSI scores below the 85th percentile). In all, 591 subjects (292 males, 299 females) were chosen through this process. Face-to-face interviews were conducted in 1979 at age 20/21 (N = 591), 1981 at age 22/23 (N = 456), 1986 at age 27/28 (N = 457), 1988 at age 29/39 (N = 424), 1993 at age 34/35 (N = 407), 1999 at age 40/41 (N = 367), and 2008 at age 49/50 (N = 335). Over that span, 57% of the original cohort continued to participate. The initial allocation to the two groups according to the cut-off value along the 85th percentile of the GSI did not change over the time span, although dropouts were rather extremely high or low scorers on the GSI (Eich et al., 2003). We repeated those dropout analyses for the last interview in 2008 and additionally found, that dropouts did not differ significantly in their socioeconomic status and education at onset of the study from subjects who remained in the study. Neither was there a difference in initial psychopathologic impairment according to the nine SCL-90-R subscales. However, there was a moderate bias with respect to sex: dropouts were rather males (OR = 1.82; 95%-CI = 1.31–2.53; $p < 0.001$). A detailed description of the sampling procedure is provided elsewhere (Angst et al., 1984; Rössler et al., 2012a). For the present study we considered only subjects who also participated in the last assessment in 2008 (191 females; 144 males).

2.2. Instrument and measures

The SCL-90-R is a comprehensive self-report questionnaire of 90 items that cover a wide variety of psychiatric symptoms. Subjects responded according to a five-point Likert scale of distress that ranged from “not at all” to “extremely”. The SCL-90-R covered the most recent four-week period of psychopathology at each measurement occasion. Its 90 items are grouped along nine subscales that reflect a broad spectrum of symptoms. We applied two subscales relevant to sub-clinical psychosis (i.e., “paranoid ideation” and “psychoticism”). The SCL-90-R has historically shown good internal consistency and test–retest reliability (Schmitz et al., 2000). However, the factor structure has led to contradictory results. Commonly, fewer than nine factors are identified (Schmitz et al., 2000), and the “psychoticism” subscale yields the least consistent results (Olsen et al., 2004). To overcome those shortcomings, we used factor-analytic methods to rearrange those psychosis subscales slightly. Our first new subscale was used to address social and interpersonal deficiencies, as evidenced by a reduced capacity for close relationships as well as ideas of reference, odd beliefs, and suspicion/paranoid ideation. As such, this factor was reminiscent of the criteria required for diagnosing a “schizotypal personality disorder”. Thus we named this new subscale “schizotypal signs”. Our second new subscale included the items of thought insertion, thought-broadcasting, thought control, and hearing voices. These symptoms represent attenuated forms of the nuclear symptoms of schizophrenia. Thus we named this the “schizophrenia nuclear symptoms” subscale. A detailed description of those subscales has been provided elsewhere (Rössler et al., 2007). In the meantime those subscales of sub-clinical psychosis have been replicated and applied in other samples (Breetvelt et al., 2010; Rössler et al., 2011a). In the present study the internal consistency (Cronbach's α) of STS over all interviews ranged from $\alpha = 0.800$ to $\alpha = 0.869$, with a mean $\alpha = 0.821$. Cronbach's α of SNS ranged from $\alpha = 0.497$ to $\alpha = 0.694$, with a mean $\alpha = 0.595$. To assess discriminant and convergent validity we correlated our psychosis subscales with the three subscales of the Schizotypal Personality Questionnaire Brief-form (SPQ-B) (Raine and Benishay, 1995), using data from the 2008 assessment wave of the Zurich Study. Pearson r values for the associations with the SPQ-B subscales cognitive–perceptual, interpersonal, and disorganized were 0.370, 0.485, and 0.357 for STS and 0.319, 0.249, and 0.228 for SNS. The correlation between STS and SNS for the measurement occasions 1979, 1981, 1986, 1988, 1993, 1999, and 2008 was 0.441, 0.537, 0.437, 0.489, 0.446, 0.496, and 0.636, respectively.

To examine the impact of different coping resources we incorporated the well-established scales of mastery and self-esteem from the work by Pearlin and Schooler (1978). Mastery describes the extent to which a subject is convinced that she or he has control and influence over personal life events and problems (e.g.: “I have little control over the things that happen to me”). Self-esteem measures a subject's positive attitude and confidence toward her- or himself (e.g., “I feel that I have a number of good qualities”). The mastery subscale comprises seven items; the self-esteem subscale, six. All questions were rated on a four-point Likert scale ranging from “completely agree” to “completely disagree”. The two subscales have shown good reliability and validity (Pearlin and Schooler, 1978; Hobfoll and Walfisch, 1984). Coping was assessed in 1979, 1986, 1993, 1999, and 2008. Because measures were highly correlated over time (all $r > 0.5$) and highly stable (i.e., participants' mean scores did not significantly change over time), we computed a mean value from those five measurements.

During the interview in 1988, we evaluated participants' personality with the Freiburger Persönlichkeits-Inventar (FPI) (Fahrenberg et al., 1984). The FPI is a popular German inventory that depicts personality traits on nine distinct subscales. Those primary traits are 1) nervousness (e.g. being anxious), 2) aggressiveness (being hostile), 3) depressiveness (being sad, gloomy), 4) irritability (being susceptible), 5) sociability (being outgoing), 6) resiliency (being calm), 7) dominance (being intrusive), 8) inhibition (being self-conscious), and 9) openness (being frank). The FPI has shown good reliability and validity (Fahrenberg et al., 1984).

All other covariates were obtained with the “Structured Psychopathological Interview and Rating of the Social Consequences of Psychological Disturbances for Epidemiology” (SPIKE) (Angst et al., 1984). This semi-structured interview, developed for epidemiological surveys in psychiatric research, evaluates data about socio-demography, somatic syndromes, psychopathology, substance use, medication, health services, impairment, and social activity. Its reliability and validity have been reported elsewhere (Angst et al., 2005). We applied the following variables related to psychosocial problems that may potentially have an immediate effect on sub-clinical psychosis symptoms: distress because of employment, partnership problems, or parents; and drug use. All variables covered the 12-month period prior to a measurement occasion and were assessed at every interview. “Employment” comprised severe conflicts at workplace, dismissal or demotion, or unemployment. “Partnership” covered severe conflicts with a partner, being left by one's partner,

or separation/divorce. "Parents" included a serious disease or the death of a parent. All those items were assessed as a self-report checklist and participants responded to each item by marking "yes" or "no". Finally, "drugs" comprised drug dependence or abuse according to DSM-IV criteria or at least weekly use as assessed during the interview. For more information on the algorithm of diagnoses see Angst et al. (2005).

2.3. Statistical analysis

There was no evidence to reject the hypothesis that the data were missing completely at random (MCAR) according to Little's MCAR test ($\chi^2 = 1595.014$, df = 1546, p = 0.188). Therefore, to obtain complete data from all 335 participants on both subscales, we conducted a missing value analysis (MVA). Altogether, 152 participants (45.4%) had at least one missing value and totally 972 values (10.4%) were imputed. No variable was missing in more than maximally 56 subjects (16.7%). MVA was carried out with the full information maximum likelihood estimation using all available data, which is a highly recommended MVA procedure (Schafer and Graham, 2002). Afterward, we fitted a latent state–trait model (LST) with Mplus version 7 for Macintosh (Muthén and Muthén, 1998–2012). LST models are performed within the framework of structural equation modeling (SEM) with repeated measures. SEM consists of a measurement model and a structural model. Using the former, researchers can depict patterns of observed variables for latent constructs (i.e. higher-order factors) in a hypothesized model. The measurement model corresponds basically to a confirmatory factor analysis. In the structural model, one may examine associations between the latent constructs using a succession of structural equations. The structural model thus resembles a multiple regression analysis. See Kline (2005) for a comprehensive introduction to SEM.

When a test or questionnaire is administered to a subject, the resulting scores or measures always consist of individual state differences that are due to variations in traits or occasions as well as person–situation interactions. By repeating a test or questionnaire over different time intervals, LST allows one to decompose variance in manifest variables into a latent state (measuring occasion specificity) and a latent trait (measuring consistency over occasions) while adjusting for the measurement error and the occasion-specific residual variance, which includes the person–situation interaction. A good example of a formal outline for latent state–trait theory is given by Steyer et al. (1999). An important part of fitting an LST model is the adequate modeling of indicator-specific effects because residuals of indicators are often interrelated over time when repeatedly measured (Sörbom, 1975). There are several approaches that allow one to account for indicator-specific effects. Here, we implemented a procedure with an indicator-specific latent factor as discussed by Eid et al. (1999). Using the LST modeling applied for Mplus as detailed by Geiser (2011), we fitted an indicator-specific latent factor that loaded exclusively on the second indicator at every measurement occasion (see Figs. 1 and 2). The first state indicator served as the reference, and the indicator-specific factor was defined as the residual factor of the state factors. Consequently, the indicator-specific factor stringently had a mean equal to zero and was uncorrelated with all state factors and with the trait factor. Predictors were defined according to a split-half approach based on the items for the respective subscale. We applied a robust maximum likelihood estimator, which is recommended because of its robustness to multivariate non-normality of continuous data (Kline, 2005). Path coefficients were reported with standardized regression coefficients (β) and their standard errors (SE). To evaluate the goodness of model fit we considered the χ^2-test of model fit and the following approximate fit indices (AFI): the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). According to the χ^2-test, a good-fitting model should provide an insignificant result (i.e., above the 0.05 threshold). However, with increasing sample sizes, a χ^2 value becomes easily significant and the test tends to reject also well-fitting models (Steiger, 2007). Recommended cut-off values of AFI for a good model fit are CFI > 0.95, TLI > 0.95, RMSEA < 0.06, and SRMR < 0.08 (Schreiber et al., 2006).

The factor score of the latent states and trait was used to analyze associations with various covariates. For this purpose we fitted a series of generalized linear models (GLM) using SPSS version 20 for Macintosh. The factor scores on the states and the trait, respectively, were entered as the dependent variable and the covariates as the independent variables. Trait-covariates were included separately and state-covariates of a given measurement occasion were entered simultaneously into the model. A robust estimator was used to reduce the effects of outliers and influential observations. All dependent variables were right skewed, thus we fitted all models with gamma distribution and log link-function. We used a series of cross-sectional analyses because state variance was computed for each measurement occasion separately. Nevertheless, the longitudinal dependency of the psychosis states was accounted for since they were estimated with the LST model. Results were reported with unstandardized regression coefficients (b) and their standard errors (SE).

3. Results

We first inspected the fit of our LST models as indicated in Figs. 1 and 2. For the STS model the χ^2 was 114.464 (df = 63), p < 0.001, the CFI was 0.977, the TLI was 0.967, the RMSEA was 0.049, and the SRMR was 0.041. Except for the χ^2-test these indices demonstrated a good model fit for STS. With respect to the SNS model the χ^2 was 70.840 (df = 63), p = 0.233, the CFI was 0.989, the TLI was 0.984, the RMSEA was 0.019, and the SRMR was 0.041, which indicates an excellent model fit. The reliability estimates (i.e. proportion of variance explained) for indicators of the STS states ranged from $R^2 = 0.693$ to $R^2 = 0.837$, with a mean $R^2 = 0.770$. Reliability estimates for SNS were somewhat lower, ranging from $R^2 = 0.431$ to $R^2 = 0.652$, with a mean $R^2 = 0.522$. The correlation matrix of the endogenous (observed) variables is given in Tables 1 and 2.

The loading coefficients of the latent variables for STS and SNS are depicted in Figs. 1 and 2. Those squared standardized loadings led to estimates of state and trait variances as indicated in Table 3. The results indicate that the proportion of variance in STS explained by the latent trait increased after age 20/21 (52.1%), peaked at age 27/28 (75.4%) before declining toward its lowest level at age 49/50 (48.8%). With respect to SNS, the variance estimates showed a less consistent trajectory. Nevertheless, similar to STS the variance related to stable trait characteristics was low at age 20/21 (38.4%) and remarkably high at age 27/28 (88.8%). With respect to both subscales the lowest proportion of variance explained by trait characteristics was obtained in at ages 20/21 and 49/50, respectively.

Various associations were tested between the latent constructs (i.e., states and trait) and different covariates. We linked the time-invariant latent trait to covariates that yielded consistent effects over time and that also represented rather stable constructs. Thus, our GLM included sex, coping, and personality. The results for trait characteristics are indicated in Table 4. With respect to STS, there were statistically significant associations with all time-invariant covariates except for sex ($-0.074 \leq b \geq 0.276$; all p < 0.004). Associations with SNS were consistently lower and yielded statistically significant associations with 9 out of 12 covariates ($0.083 \leq b \geq 0.201$; all p < 0.002). In both subscales the largest effect was found for depressiveness. Adaptive personality traits were negatively related to STS and SNS, whereas maladaptive traits showed positive associations.

We then related the latent states to time-specific effects — that is, covariates that varied across measurement occasions. This meant that GLMs were computed for each occasion separately (see Table 5). STS was significantly related to employment distress at age 22/23, 29/30, 40/41, and 49/50 ($0.063 \leq b \geq 0.077$, all p < 0.007). Partnership problems

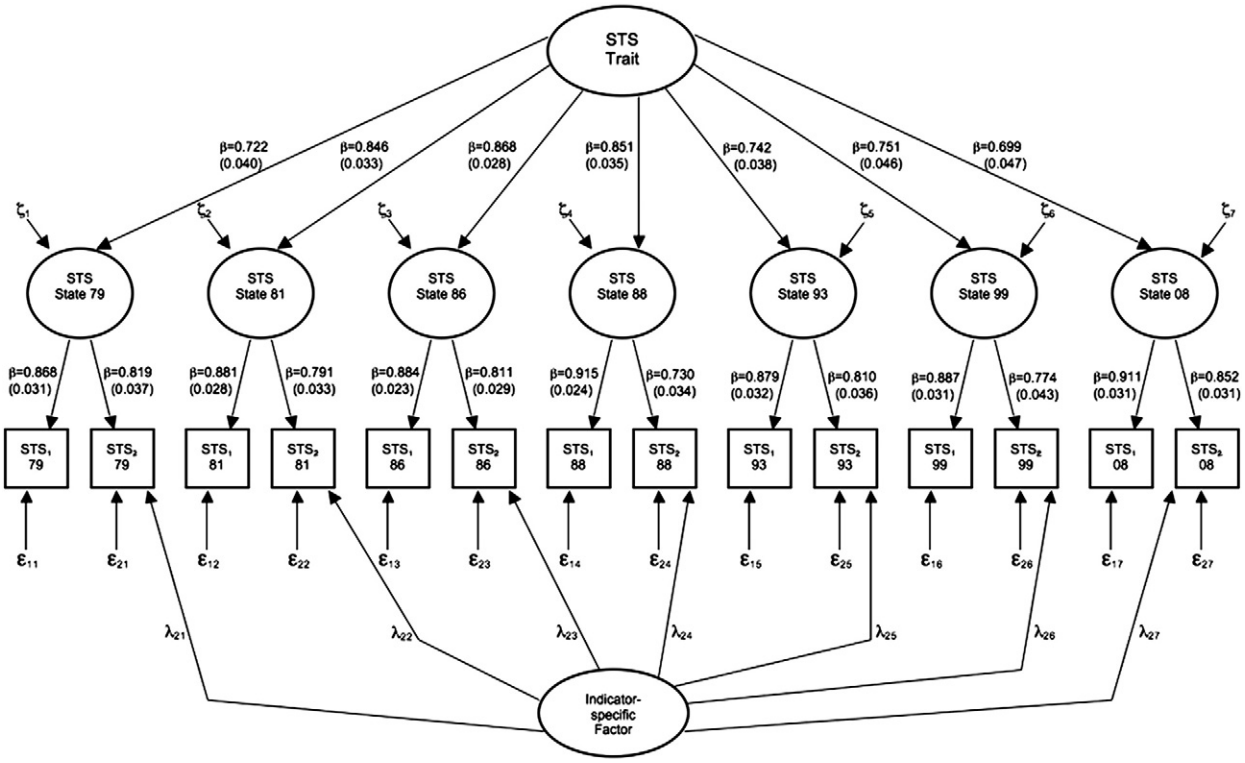

Fig. 1. Latent state–trait model for schizotypal signs (STS) repeatedly measured between 1979 and 2008 (7 occasions). ζ_k: latent state residual; ε_{ik}: measurement error; λ_{ik}: factor loading parameter (i = indicator, k = occasion of measurement). Standard errors are reported in parentheses.

were associated with STS throughout the observation period from age 22/23 to 49/50 ($0.059 \leq b \geq 0.140$; all $p < 0.049$). Finally, drug-use was related to STS at age 20/21 ($b = 0.154$, $p < 0.001$). As for SNS, partnership problems were significantly related to at age 27/28 ($b = 0.053$, $p = 0.019$), 29/30 ($b = 0.070$, $p = 0.012$), 40/41 ($b = 0.040$, $p = 0.028$), and 49/50 ($b = 0.037$, $p = 0.037$). Drug-use yielded a significant association at age 20/21 ($b = 0.113$, $p = 0.003$). Again, associations were considerably stronger for STS when compared to SNS.

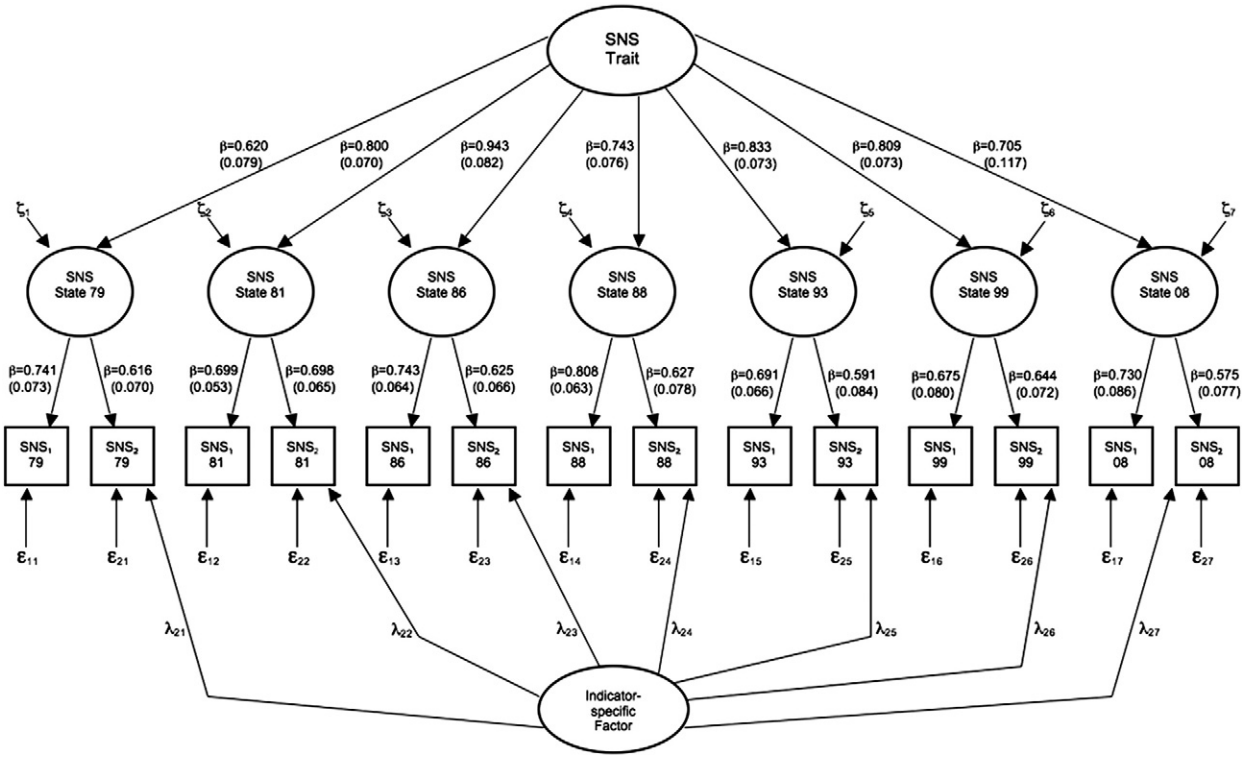

Fig. 2. Latent state–trait model for schizophrenia nuclear symptoms (SNS) repeatedly measured between 1979 and 2008 (7 occasions). ζ_k: latent state residual; ε_{ik}: measurement error; λ_{ik}: factor loading parameter (i = indicator, k = occasion of measurement). Standard errors are reported in parentheses.

Table 1
Observed variables in the SEM for STS: correlation matrix below the diagonal, variance estimates on the diagonal, and residual correlations (discrepancies) above the diagonal.

	ST1 '79	ST1 '81	ST1 '86	ST1 '88	ST1 '93	ST1 '99	ST1 '08	ST2 '79	ST2 '81	ST2 '86	ST2 '88	ST2 '93	ST2 '99	ST2 '08
STS1 '79	0.140	0.014	0.001	−0.005	−0.001	−0.004	−0.003	0.000	0.006	0.002	−0.003	−0.003	−0.003	−0.001
STS1 '81	0.567	0.129	0.003	0.002	−0.002	−0.009	−0.001	0.009	−0.001	−0.002	−0.004	−0.006	−0.007	−0.004
STS1 '86	0.486	0.594	0.115	0.004	−0.003	−0.005	−0.004	−0.001	0.006	0.001	0.006	0.002	−0.004	−0.003
STS1 '88	0.447	0.592	0.629	0.112	0.000	0.002	−0.005	0.000	0.002	0.005	0.002	0.003	0.002	−0.001
STS1 '93	0.397	0.467	0.473	0.502	0.105	0.005	0.006	−0.005	−0.002	0.000	−0.001	0.000	0.007	0.005
STS1 '99	0.389	0.422	0.471	0.539	0.478	0.114	0.016	−0.003	−0.008	−0.003	−0.001	0.004	0.000	0.015
STS1 '08	0.375	0.464	0.457	0.451	0.468	0.561	0.119	−0.005	−0.004	−0.008	−0.003	0.002	0.013	−0.001
STS2 '79	0.710	0.502	0.446	0.459	0.347	0.368	0.339	0.146	0.019	0.002	0.000	−0.011	−0.005	−0.002
STS2 '81	0.466	0.692	0.564	0.534	0.425	0.382	0.396	0.590	0.136	0.006	0.000	−0.008	−0.009	−0.010
STS2 '86	0.454	0.506	0.725	0.582	0.454	0.445	0.382	0.496	0.622	0.134	0.005	0.000	−0.004	−0.006
STS2 '88	0.364	0.424	0.524	0.677	0.390	0.407	0.368	0.441	0.534	0.613	0.126	0.002	−0.001	−0.007
STS2 '93	0.351	0.393	0.482	0.494	0.714	0.434	0.397	0.347	0.467	0.568	0.554	0.116	0.007	0.005
STS2 '99	0.339	0.377	0.411	0.470	0.438	0.685	0.481	0.376	0.430	0.507	0.497	0.566	0.117	0.017
STS2 '08	0.366	0.412	0.431	0.453	0.429	0.523	0.774	0.379	0.395	0.456	0.406	0.493	0.570	0.129

4. Discussion

To the best of our knowledge, this is the first study to determine the proportion of variance explained in sub-clinical psychosis related to latent states and trait characteristics over a 30-year span. We analyzed data from the prospective Zurich cohort study and fitted a latent state–trait (LST) model for two subscales derived from the well-established SCL-90-R. A latent state typically comprises transient effects specifically related to a particular measurement occasion, such as age-related and environmental factors, whereas a latent trait describes time-invariant and rather consistent effects, such as personality. In subsequent generalized linear model (GLM) analyses, we examined the associations of various covariates with the latent states and trait to determine which covariates might account for the variance in both sub-clinical psychosis syndromes.

The LST model revealed several important findings. First, with respect to STS between age 22 and 30 the latent trait underlying the occurrence of the syndrome explained considerably more variance in sub-clinical psychosis than did the latent-state variables. That is, over this time period, the variance in STS tended to be associated to a stable and enduring liability rather than to a time-dependent, fluctuating, and occasion-specific liability. Second, with respect to SNS, we found a strong impact by a time-dependent state at age 20/21 that explained 61.6% of the variance and a considerably strong effect of a trait at age 27/28 (88.8% of variance). Third, and presumably most importantly, the variance components of state and trait differed substantially over a subject's lifespan. For both syndromes, the variance attributable to states was highest at age 20/21 and 49/50, whereas the variance related to traits was greatest at age 27/28. That means that occasion-specific determinants of STS, and in particular SNS, were influential in 1979 and 2008 when participants were aged around 20 and 50 years, respectively. Contrariwise those determinants could only slightly account for the variance in sub-clinical psychosis when participants were about 28 years old (in 1986). The results of the GLM showed that the stable trait underlying the variance in the occurrence of both sub-clinical psychosis syndromes was related to various personality dimensions, in particular depressiveness (as a feature of neuroticism), and a low sense of mastery and self-esteem. This association was considerably stronger for STS. The time-dependent states underlying the variance in STS were primarily related to employment problems and to partnership problems between ages 27 and 50. However, the strongest association was yielded by drug-use at age 20/21. Variance related to SNS was likewise most importantly attributed to drug-use at age 20/21 and to partnership problems between ages 27 and 50.

In this study we had the opportunity to analyze two syndromes of sub-clinical psychosis that encompass important features of schizotypy as well as nuclear symptoms of schizophrenia. That is, our syndromes covered a broad range of rather stable symptoms (schizotypal signs) and more transient symptoms (schizophrenia nuclear symptoms) along the schizophrenia spectrum. It is obvious that the occurrence of psychosis symptoms represents a multifactorial development. Whether psychosis symptoms occur and how persistent they are depends on the degree how significant factors interact with each other. Schizotypy refers by definition to the personality trait or proneness of experiencing psychosis symptoms. But the variance underlying the expression of this trait is also age-dependent as well as occasion-specific.

Our results indicated that, overall, more than half and, at certain ages, even a preponderant majority, of the variance could be explained by a latent trait, that, exceeding a certain threshold, would represent a stable liability for sub-clinical psychosis. However, we have also recently shown that symptoms of sub-clinical psychosis are a risk factor for subsequent common mental disorders, including obsessive–compulsive disorder or bipolar disorder (Rössler et al., 2011b). Thus, the trait related to the vulnerability to psychosis symptoms constitutes a tendency not

Table 2
Observed variables in the SEM for SNS: correlation matrix below the diagonal, variance estimates on the diagonal, and residual correlations (discrepancies) above the diagonal.

	SN1 '79	SN1 '81	SN1 86	SN1 '88	SN1 '93	SN1 '99	SN1 '08	SN2 '79	SNS2 '81	SNS2 '86	SNS2 '88	SNS2 '93	SNS2 '99	SNS2 '08
SNS1 '79	0.124	0.009	0.003	−0.003	−0.012	−0.006	0.002	0.001	0.005	0.004	−0.002	−0.004	0.000	0.003
SNS1 '81	0.344	0.097	−0.001	−0.006	−0.002	0.002	−0.005	0.016	0.001	0.007	−0.003	0.000	0.003	−0.005
SNS1 '86	0.363	0.377	0.057	0.003	0.000	0.001	−0.001	−0.001	−0.001	−0.001	−0.003	−0.002	−0.002	−0.002
SNS1 '88	0.245	0.255	0.466	0.066	0.005	0.000	−0.003	−0.002	0.002	0.002	0.000	−0.001	−0.001	0.000
SNS1 '93	0.121	0.290	0.399	0.417	0.056	0.001	0.004	−0.007	0.000	0.001	0.004	0.000	0.002	0.002
SNS1 '99	0.175	0.331	0.401	0.327	0.334	0.042	0.000	−0.003	0.002	−0.001	−0.003	0.002	0.000	0.002
SNS1 '08	0.260	0.217	0.350	0.250	0.373	0.276	0.045	0.000	0.002	−0.002	0.004	0.004	0.002	0.001
SNS2 '79	0.462	0.351	0.251	0.208	0.141	0.164	0.195	0.146	0.006	0.005	−0.002	−0.002	0.000	−0.001
SNS2 '81	0.296	0.495	0.379	0.356	0.311	0.326	0.313	0.371	0.113	−0.005	0.009	0.005	−0.005	−0.004
SNS2 '86	0.313	0.407	0.450	0.373	0.350	0.299	0.266	0.390	0.363	0.073	0.000	−0.001	0.003	−0.002
SNS2 '88	0.191	0.227	0.281	0.505	0.329	0.201	0.313	0.301	0.467	0.383	0.068	−0.003	−0.001	0.002
SNS2 '93	0.180	0.280	0.301	0.279	0.414	0.317	0.333	0.333	0.451	0.401	0.328	0.053	0.000	0.003
SNS2 '99	0.244	0.339	0.321	0.286	0.328	0.433	0.309	0.328	0.323	0.457	0.353	0.397	0.055	0.003
SNS2 '08	0.225	0.155	0.246	0.242	0.268	0.260	0.435	0.263	0.254	0.301	0.331	0.390	0.380	0.043

Table 3
Deconstruction of variance in schizotypal signs (STS) and schizophrenia nuclear symptoms (SNS) into latent state and trait estimates.

Variance estimates				
Age	STS		SNS	
	State	Trait	State	Trait
	R^2 (95% CI)	R^2 (95% CI)	R^2 (95% CI)	R^2 (95% CI)
20/21	0.479 (0.366; 0.592)	0.521 (0.407; 0.635)	0.616 (0.423; 0.808)	0.384 (0.192; 0.576)
22/23	0.285 (0.176; 0.394)	0.715 (0.605; 0.825)	0.360 (0.141; 0.578)	0.640 (0.420; 0.860)
27/28	0.246 (0.150; 0.342)	0.754 (0.658; 0.850)	0.112 (0.000; 0.415)	0.888 (0.584; 1.000)
29/30	0.276 (0.161; 0.392)	0.724 (0.608; 0.840)	0.448 (0.227; 0.669)	0.552 (0.331; 0.773)
34/35	0.449 (0.338; 0.561)	0.551 (0.439; 0.663)	0.306 (0.069; 0.543)	0.694 (0.457; 0.931)
40/41	0.436 (0.302; 0.570)	0.564 (0.429; 0.699)	0.345 (0.113; 0.577)	0.655 (0.422; 0.888)
49/50	0.512 (0.384; 0.640)	0.488 (0.361; 0.615)	0.503 (0.179; 0.827)	0.497 (0.174; 0.820)

only toward schizophrenia (even though none of the participants of this study has developed schizophrenia so far), but also toward a wide range of psychopathology. The expression of both STS and SNS can be moderated by personality dimensions (i.e., traits), such as a sense of mastery, or by depressiveness. Associations between normal personality traits and schizotypy have been reported previously (Dinn et al., 2002; Ross et al., 2002; Asai et al., 2011). Both syndromes can also be moderated by more transient psychosocial problems (i.e., states). The impact of psychosocial problems (partnership, employment) illustrates that sub-clinical psychosis is also a disorder of social interaction, which is comparable to social functioning deficits in schizotypal personality disorder (Hengartner et al., 2013a,b). Consequently this finding refers especially to schizotypal signs, and not as much to schizophrenia nuclear symptoms, which seem to be less associated with environmental factors (Rössler et al., 2007). This is a striking finding when we take into account that schizotypy was defined as a stable personality trait (Raine, 2006). However, Raine hypothesized two subtypes of schizotypy, whereof one was defined as a rather transient condition with considerable symptom fluctuations. Furthermore, it has consistently been shown that personality traits across the whole range from adaptive (normal personality functioning) to maladaptive (personality disorders) are highly related to transient environmental factors and gene–environment interactions (McCrae et al., 2005; Livesley and Jang, 2008). Just as a state such as hallucinations is not per se unrelated to trait liability, a trait-like condition is not necessarily unsusceptible to state liability. Accordingly, drug-use during youth and early adulthood is another potential instant and transient modifier for both syndromes, which we have also demonstrated in a previous analysis (Rössler et al, 2012a). Associations between substance-use in adolescence (Moore et al., 2007; Barkus and Murray, 2010) and psychosocial stressors (Nuevo et al., 2012) with psychotic symptoms have been reported consistently in the literature. By contrast, sex does not appear to play a significant role as a moderator (Scott et al., 2006; Wiles et al., 2006; Rössler et al., 2012b). In conclusion, although most psychosis symptoms are transient and episodic in nature, the variability in their expression is predominantly caused by stable traits. The impact of those traits is moderate around ages 20 and 50, but highly predominant around age 30. Most important underlying traits are in particular depressiveness (representing a feature of neuroticism) and low sense of mastery and self-esteem (representing coping resources).

Table 4
Factor scores of the latent trait of schizotypal signs (STS) and schizophrenia nuclear symptoms (SNS) in association with time-invariant covariates.

Covariate	STS			SNS		
	b	SE	Sig.	b	SE	Sig.
Male sex	−0.015	0.045	0.742	−0.005	0.052	0.924
Self-esteem	−0.195	0.019	0.000	−0.146	0.026	0.000
Sense of mastery	−0.218	0.018	0.000	−0.162	0.023	0.000
Nervousness	0.183	0.020	0.000	0.127	0.029	0.000
Aggressiveness	0.148	0.021	0.000	0.147	0.028	0.000
Depressiveness	0.276	0.016	0.000	0.201	0.024	0.000
Irritability	0.181	0.021	0.000	0.147	0.028	0.000
Sociability	−0.074	0.025	0.003	−0.023	0.032	0.473
Resiliency	−0.130	0.022	0.000	−0.039	0.029	0.175
Dominance	0.162	0.021	0.000	0.126	0.027	0.000
Inhibition	0.154	0.022	0.000	0.109	0.026	0.000
Openness	0.119	0.020	0.000	0.083	0.025	0.001

The results of this study are also relevant for clinical practice. Firstly, it is important to emphasize that sub-clinical psychosis symptoms are not necessarily indicators of the onset of full-blown psychosis, in fact the majority of cases with these symptoms remain on the level of sub-clinical psychosis. This does not mean that the affected persons are not in need of treatment as these psychopathological sub-threshold states go along with significant psychosocial impairments (Rössler et al., 2007, 2012b). Secondly, it has been a matter of intensive discussions whether and how substance use may contribute to the risk of psychosis. Our results indicate that there is an increased risk for sub-clinical psychosis symptoms for vulnerable individuals. As long as we cannot identify those individuals at risk the recommendation to sustain from substance use applies to all individuals. And thirdly, psychosocial interventions might be helpful for vulnerable individuals. As we could demonstrate mastery and self-esteem are helpful personality traits in coping with or even in preventing psychosis symptoms. Interventions directed toward strengthening self-esteem and mastery might be helpful for individuals to cope with their liability for psychosis.

This study was subject to several methodological shortcomings, including an initially small sample size that was then further reduced through attrition. Although missing values were missing completely at random we may not exclude a certain bias caused by dropouts and missings. The longitudinal data analyzed here relied on self-report instruments, for which responses might have been biased by denial or a minimization of symptoms. Next, some intervals were quite long between measurement occasions, making it impossible for us to determine whether participants had experienced psychotic symptoms during those gaps that were not covered by the interviews. Our data do not allow for causal inference in a strict way, as the data are observational and cross-sectionally analyzed. Our observed variables entered in the structural equation model were not multivariate normally distributed (analyses not shown here). To account for this we chose an estimator robust to the violation of normality. Except for the first assessment in 1979, variance of our psychosis subscales was rather low and kurtosis was highly positive, which indicates a heavy peakedness of the distribution. This may have influenced our estimates of states and trait. Finally, some of the reliability and validity measures of the psychosis subscales were not satisfactory. Nevertheless, we contend that these results do contribute significantly to the discussion about sub-clinical psychosis because they arise from longitudinal data from a representative community sample that spanned a 30-year period.

Table 5
Factor scores of the latent states of schizotypal signs (STS) and schizophrenia nuclear symptoms (SNS) in association with time-dependent covariates.

Age	Employment b (SE); Sig.	Partnership b (SE); Sig.	Parents b (SE); Sig.	Drugs b (SE); Sig.
Covariates of STS				
20/21	0.026 (0.023); 0.258	0.025 (0.023); 0.275	0.035 (0.025); 0.156	0.154 (0.039); 0.000
22/23	0.077 (0.028); 0.006	0.059 (0.023); 0.010	0.043 (0.034); 0.199	0.026 (0.037); 0.491
27/28	0.026 (0.027); 0.333	0.140 (0.027); 0.000	0.039 (0.032); 0.226	0.010 (0.033); 0.751
29/30	0.074 (0.025); 0.003	0.095 (0.032); 0.003	0.017 (0.035); 0.628	0.003 (0.045); 0.948
34/35	0.014 (0.029); 0.625	0.102 (0.052); 0.048	0.061 (0.036); 0.091	0.036 (0.047); 0.441
40/41	0.063 (0.022); 0.004	0.081 (0.029); 0.006	0.026 (0.028); 0.355	0.040 (0.043); 0.362
49/50	0.071 (0.025); 0.004	0.115 (0.030); 0.000	0.048 (0.029); 0.092	0.046 (0.061); 0.451
Covariates of SNS				
20/21	−0.010 (0.020); 0.620	0.031 (0.020); 0.127	0.045 (0.023); 0.052	0.113 (0.038); 0.003
22/23	0.033 (0.023); 0.139	0.007 (0.018); 0.712	−0.025 (0.023); 0.272	0.005 (0.033); 0.888
27/28	−0.003 (0.020); 0.873	0.053 (0.023); 0.019	0.000 (0.022); 0.991	0.014 (0.029); 0.628
29/30	−0.020 (0.018); 0.265	0.070 (0.028); 0.012	0.023 (0.026); 0.381	0.036 (0.040); 0.374
34/35	0.016 (0.020); 0.398	0.011 (0.028); 0.701	0.042 (0.025); 0.101	0.043 (0.032); 0.174
40/41	0.002 (0.012); 0.837	0.040 (0.018); 0.028	0.024 (0.017); 0.170	0.027 (0.030); 0.360
49/50	−0.001 (0.013); 0.964	0.037 (0.018); 0.037	0.022 (0.018); 0.231	0.054 (0.047); 0.253

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Contributors

Wulf Rössler took responsibility for all assessment waves since 1999, and also drafted and revised the manuscript. Michael Hengartner conducted all statistical analyses and substantially contributed to drafting and critical revision of the manuscript. Vladeta Ajdacic-Gross and Helene Haker substantially contributed to drafting and critical revision of the manuscript. Jules Angst designed the study, was responsible for assessment waves until 1993, and substantially contributed to drafting and critical revision of the manuscript.

Conflict of interest

None.

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