Schizotypy unfolding into the night? Schizotypal traits and daytime psychotic-like experiences predict negative and salient dreams

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ABSTRACT

Symptoms of insomnia and frequent nightmares are prevalent in psychotic disorders, and are associated with psychotic-like experiences (PLEs) in the non-clinical population. Whereas the role of impaired sleep in psychosis was extensively examined by longitudinal and interventional approaches, studies on the association between psychosis and dream quality are scarce, and mainly cross-sectional. We conducted a three-week long prospective study in a group of healthy adults ($N = 55$), assessed schizotypal traits, daily PLEs, and the emotional quality of dreams recalled in the morning ($N = 490$). We extracted the latent factors of schizotypal traits and dream emotions, and examined the predictive value of trait-and state-like variables on day-to-day reports of PLEs and dream quality. PLEs reported in the evening predicted emotionally more negative and salient dream reports the following morning. On the other hand, the quality of dreams were not predictive of PLEs reported later during the day. Schizotypal personality traits were differentially associated with dream quality: *Introvertive Anhedonia*, *Cognitive Disorganization*, and *General-Disorganized schizotypy* were linked to more negative dream valence, whereas *Unusual Experiences* were associated with more salient dreams. Our findings highlight the relevance of the multidimensional nature of schizotypal traits, the role of different facets of schizotypy in daytime and nocturnal mental experiences, and the day-to-day associations between PLEs and dream affect.

General scientific summaries (GSS): The aim of the study was to examine the temporal associations between psychotic-like experiences and dream emotions, taking into account the trait factors of schizotypy. Psychotic-like experiences during the evening hours predicted reporting more negative and salient dreams the following morning, and schizotypal personality traits were differentially associated with the dimensions of dream emotions.

1. Introduction

Perceptual distortions, disorganized thoughts, paranoid ideation, and delusion-like beliefs coined as psychotic-like experiences (PLEs) are relatively common among non-clinical individuals in the general population (Linscott and van Os, 2013; Rössler et al., 2015; van Os et al., 2009), and although sub-clinical, they represent a risk for the development of psychotic disorders (Hanssen et al., 2005; Kelleher and Cannon, 2011; Welham et al., 2009) . Occurrence of PLEs in healthy individuals is associated with psychosis-related social, environmental, and neuro-cognitive risk factors (Kelleher and Cannon, 2011; Linscott and van Os, 2013; van Os et al., 2009), and proneness to PLEs appears to be a heritable trait that covaries with genetic risk for schizophrenia-spectrum disorders and various other mental disorders (Barkhuizen et al., 2020; Ronald and Pain, 2018; Zavos et al., 2014). Studying non-clinical psychotic phenomena is a fruitful approach to understand the etiology, progression, and relapse of psychotic disorders (Kelleher and Cannon, 2011; van Os et al., 2009), devoid of the confounding effects of co-morbidity and other nonspecific factors of disease burden, medication, or hospitalization(O. J. Mason, 2015). Moreover, PLEs show remarkable day-to-day variability even in healthy individuals (Barrantes-Vidal et al., 2013; Cristóbal-Narváez et al., 2017; P. Simor et al., 2019), allowing to examine the variables that contribute to the dynamic occurrence of subtle psychotic-like phenomena over consecutive days.

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Recent studies indicate that PLEs within individuals are temporally preceded by impaired sleep in diverse samples. In addition, PLEs may predict sleep quality the following night as well (Hennig et al., 2020; Hennig and Lincoln, 2018; P. Simor et al., 2019), although this finding is less consistent (Hennig and Lincoln, 2018; P. Simor et al., 2019). These findings are in line with studies indicating the crucial role of sleep quality in the development and persistence of psychotic states (J. Barton et al., 2018; Reeve et al., 2015) . Although sleep problems were reported by a huge proportion (50–80%) of patients with non-affective psychosis (Freeman et al., 2020), and about 75% of patients with schizophrenia reported that their sleep problems occurred before the onset of persecutory delusions (Freeman et al., 2019), sleep disorders are usually considered epiphenomenal, and hence, are largely neglected in the evaluation and treatment of psychotic disorders (Reeve et al., 2019). Nevertheless, a growing number of studies suggest that disturbed sleep is a contributory causal factor in psychotic conditions (Freeman et al., 2020; Kumari and Ettinger, 2020; Waite et al., 2020).

Beyond poor sleep quality and symptoms of insomnia, nightmares are the other most common sleep problem linked to psychosis (Reeve et al., 2019; Sheaves et al., 2015). Nightmares are intense and emotionally negative dreams that usually end in abrupt awakenings (T. Nielsen and Carr, 2017). Having frequent nightmares is a clinically relevant complaint as it is associated with poor sleep quality (Li et al., 2010), psychotic experiences (Rek et al., 2017; Sheaves et al., 2015), suicidal tendencies (Nadorff et al., 2011), and generally more severe psychopathological symptoms in patients (van Schagen et al., 2017). Although frequent nightmares are considered as a pathological form of dreaming (Medicine and of S., 2014), the emotional quality of dreams rather form a continuum from less severe to more dysphoric oneiric experiences, and the unpleasantness-pleasantness dimension of dreaming is associated with mental health indices (Bódizs et al., 2008; Sikka et al., 2018).

Recently, Hennig and colleagues (Hennig et al., 2020) reported that unpleasant dreams temporally predicted increased paranoid symptoms (and at a trend level, vice versa). Nevertheless, the valence of dreams was assessed by a single item coded into a three-point variable, limiting the assessment of the emotional quality of dreams that exhibit a wider and more refined array of emotional states (Conte et al., 2020; T. A. Nielsen et al., 1991; Sikka, 2020) . Moreover, the questions about PLEs and dreaming were sent at the same time point in the evening, that is, participants had to recall and rate their (previous night's) dreams in the evening. Since dreams are vague, fragmented and hardly recollectable experiences even in the morning after awakening (Koulack and Goodenough, 1976; Schredl, 2007), self-ratings about dreams twelve or more hours after morning awakenings may be prone to retrospective bias. Likewise, if daytime PLEs and previous night's dream valence are reported at the same time, it is questionable whether their statistical correlation validly reflects a temporal (day-to-day) association and whether it is not inflated by response bias tendencies(Schroeder and Costa, 1984) . In sum, in spite of this intriguing finding, the temporal association between dreaming and PLEs remains to be clarified. Therefore, we performed a three-week long prospective study to examine the bidirectional, temporal links between dream emotions and daytime PLEs, taking into consideration schizotypal personality traits. We hypothesized that the quality of dreams assessed in the morning would predict PLEs the following day, and vice versa, daytime PLEs would be associated with dream emotions the following night.

2. Methods

2.1. Participants

Non-clinical individuals ($N = 55$) with high dream recall took part in the study, selected from a larger pool ($N = 535$) of undergraduate university students (see Table 1 for sample characteristics). Exclusion criteria were (i) current or prior history of neurological, psychiatric, or

Table 1
Descriptive statistics.

	Cross-sectional assessment	Prospective assessment
Descriptive statistics		
$\sum$ N	535	55
Female (N) %	418 (78%)	42 (76%)
Male (N) %	117 (21%)	13 (24%)
Mean age (SD)	21.88 (3.92)	21.24 (2.96)
Mean BDI (SD)	5.15 (4.40)	5.22 (4.01)
Mean Unusual Experiences OLIFE (SD)	4.29 (2.74)	4.76 (2.68)
Mean AIS (SD)	5.21 (3.36)	5.16 (2.89)
Dream frequency of the participants		
Never (%)	5 (<1%)	0
About once a 2–3 month (%)	32 (~6%)	1 (<1%)
About once a month (%)	39 (~7%)	1 (<1%)
About 2–3 times a month (%)	62 (~11%)	0
About once a week (%)	124 (~23%)	3 (~5%)
Several times a week (%)	189 (~35%)	34 (~61%)
Almost every morning (%)	84 (~15%)	16 (~29%)

Note. Descriptive statistics of the sample. The columns show the descriptive statistics of the cross-sectional and the prospective phase. BDI - Beck Depression Inventory. OLIFE - Oxford-Liverpool Inventory of Feelings and Experiences. AIS - Athens Insomnia Scale.

chronic somatic diseases, (ii) taking medications (except contraceptives), (iii) 24 or higher scores on the short form of Beck Depression Inventory (BDI) (Reynolds and Gould, 1981; Rózsa et al., 2001) which indicates moderate depression according to the norms established in Hungarian samples, (iv) experience of any life-stress event over the past 3 months that might have influenced the person's daytime affect and/or sleep quality. Additionally, to provide sufficient data on dreaming, we enrolled participants who reported higher dream recall. Almost all participants who were enrolled in the study reported remembering dreams "almost every day" or "several times over a week", according to a standardized dream recall frequency scale (Schredl, 2004) (see dream recall rates in Table 1 for more details). A more detailed description of the selection procedure is provided in the Supplement. The study was approved by the Hungarian Ethical Committee for Psychological Experiments, and participants provided written-informed consent.

2.2. Procedure

Participants completed short questionnaires three times a day through an online platform: (1) a morning questionnaire assessing subjective sleep quality and dream emotions concerning the past night, (2) an afternoon questionnaire that consisted of items about mood and PLEs, and (3) an evening questionnaire of similar items. In the case of daytime surveys, participants were asked to report their experiences concerning the last couple of hours that passed between the current and the previous survey. Morning questionnaires were available between 5:00 and 12:00 am, afternoon and evening questionnaires were available between 13:00–18:00 and between 19:00 pm and 02:00 am, respectively. We asked participants to complete the morning questionnaire upon awakening, and to complete the evening questionnaire always before going to sleep. The data were collected between April and October in 2019.

2.3. Instruments

2.3.1. Screening and trait-like measures

Schizotypal personality traits were assessed with the *Oxford-Liverpool Inventory of Feelings and Experiences* (O-LIFE (O. Mason et al., 2005)). The scale consists of 43 self-report "yes/no" items grouped into four subscales: (i) Unusual experiences (12 items; magical ideation and perceptual anomalies), (ii) Cognitive Disorganization (11 items; loose

semantic associations, concentration problems and social anxiety), (iii) Introvertive Anhedonia (10 items; experiencing reduced hedonic capacity and motivation), and (iv) Impulsive Nonconformity (the latter items were excluded from the analyses given the controversial validity of this subscale (Lin et al., 2013)). Confirmatory factor analysis was used to extract latent variables (see details in Supplement). The best fitting 3-factor bifactor model included three specific factors for *Unusual Experiences, Cognitive Disorganization* and *Introvertive Anhedonia,* and a general factor. The general factor had particularly strong loadings on Cognitive Disorganization items, in line with the conjecture that cognitive disorganization is a core feature of schizotypal personality (Meehl, 1962; Polner et al., 2019). We coined this factor *General-Disorganized schizotypy*. In subsequent analyses, latent scores extracted from the model were used to estimate the effects of schizotypal personality traits.

2.3.2. Daily measures

In the *Morning Questionnaire*, participants rated the quality of their sleep based on a 8-point single item. Additionally, they were asked if they remembered their dreams. Dreaming was defined broadly, referring to any recollection of mental activity (images, thoughts, emotions, etc.) that occurred during sleep. In case they remembered, they were asked to indicate on a 5-point scale how the following emotions characterized their dreams the last night: joy, remorse, satisfaction, surprise, fear, curiosity, sadness, security, anger, shame, and insecurity. The present analysis focused only on dream quality, the items concerning sleep quality were not analyzed in the present study.

The *Daytime Questionnaires* included 8 Likert-items that covered paranoid thoughts, aberrant salience/perceptual anomalies, and cognitive disorganization. The specific items were selected from two different questionnaires (Cristóbal-Narváez et al., 2017; O. J. Mason et al., 2008) and were slightly modified to adapt them for the momentary assessment of psychotic-like states (see (P. Simor et al., 2019) for more details). The scale showed good psychometric properties and proved to be an efficient instrument to quantify day-to-day fluctuations in PLEs in previous studies (P. Simor et al., 2019; Peter Simor et al., 2020). Mood during the day was assessed with a single item (e.g., My mood in the last couple of hours was… 0: very bad, depressed, distressed..0.7: very good, joyful, very positive).

2.4. Data analyses

Data was analyzed with R (version 4.0.3 (Team and R. C, 2014)) in RStudio (Rs. Team, 2015), using the *tidyverse* (Wickham and RStudio, 2021), the *lme4*, the *factoextra*, the *lavaan*(Rosseel et al., 2017), the *semTable*, and the *MuMIn*(K. Barton and Barton, 2015) packages. Data and analyses scripts can be found at: https://osf.io/m8vg6/

2.4.1. The dimensionality of dream emotions:

First, the dimensionality of dream emotions was evaluated with a principal component analysis. As the scree plot had a clear elbow at the 3rd component, we retained the first two principal components, which explained 36.6% and 19.8% variance, respectively. The first component clearly indicated *positive valence* (see loadings in Fig. 1). Curiosity and surprise had rather weak loadings on the first, and particularly strong positive loadings on the second component, while the other emotions had varying positive loadings on this second component, that we will refer to as the *salience/emotional intensity* of dreaming.

2.4.2. Results of confirmatory factor analysis of PLEs

Then, we performed a multilevel (measurements nested within subjects) confirmatory factor analysis to evaluate the internal validity of the PLE scale. Modification indices suggested that at the within-subject level, residual covariances should be modelled between 3 pairs of items that had similar content (aberrant salience, difficulty controlling thoughts, and paranoid ideation/ideas of reference). After these were
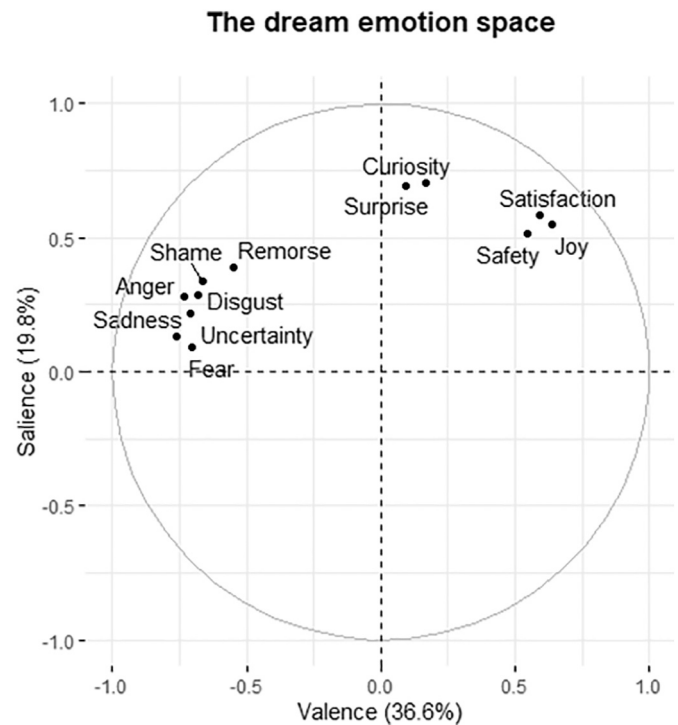

Fig. 1. The dream emotion space discovered in our sample.
Note. Participants rated their dreams (*N[dreams]* = 490) along 11 emotional dimensions and their responses were subjected to a principal component analysis. The first two components together explained 56.8% of the variance in emotional ratings. As illustrated in the figure, the first component captured valence while the second component described salience/emotional intensity.

added, a model with a single PLE-factor both at the within- and the between-subject level had excellent fit (fitted with robust maximum likelihood, robust CFI = 0.970, robust TLI = 0.954, robust RMSEA [95% CI] = 0.041 [0.033–0.050], robust SRMR within / between = 0.025 / 0.062, see details in Table 2). Latent scores based on this model were extracted to estimate daytime PLEs and were used in subsequent analyses.

2.4.3. Bidirectional temporal associations between PLEs and dream emotions

Next, we evaluated hypotheses about the reciprocal relationships between dream emotionality and daytime PLEs, while also considering the effects of schizotypal traits. We used model-averaging, a data-driven approach to improve the quality of prediction by considering all possible combinations of predictors. Model averaging is an approach of finding the best models, assigning a weight to each model, and combining them in order to deal with the uncertainty of coefficient estimates from single models. A large set of multilevel linear regression models were fitted and averaged, weighted by the corrected Akaike Information Criterion (AICc). Information theoretic model averaging is superior to the evaluation of single models, as it handles the uncertainty inherent in single coefficient estimates(Harrison et al., 2018). In order to achieve more conservative estimates, we used the 'full average' approach that does not seem to have a tendency to bias away from zero; it assumes that every predictor is included in every model, but their coefficient and its variance are set to zero in some models (see (Burnham and Anderson, 2002)). Model averaging was performed on partially standardized coefficients, which is recommended when averaging models that include different sets of predictors (Cade, 2015). The models were built including all possible combinations of trait-like factors (time-invariant variables such as dimensions of trait schizotypy, and within person means of mood and dream emotions across all time points) and state-like

Table 2
Multilevel confirmatory factor analysis of the scale used to measure psychotic-like experiences in the experience sampling phase ($N = 55$).

	Standardized factor loadings
Within-person	
Thoughts strange or unusual	0.53
Unusual sight, hearing or sense of smell	0.37
Familiar things strange and unusual	0.41
Difficulty controlling my thoughts	0.54
People doing things to annoy me	0.37
Difficulty thinking clearly	0.53
Could almost hear thoughts	0.44
Others watching me	0.35
Between-person	
Thoughts strange or unusual	0.56
Unusual sight, hearing or sense of smell	0.56
Familiar things strange and unusual	0.56
Difficulty controlling my thoughts	0.46
People doing things to annoy me	0.43
Difficulty thinking clearly	0.51
Could almost hear thoughts	0.52
Others watching me	0.48
	Residual covariances
Difficulty controlling my thoughts ~ difficulty thinking clearly	0.15
Unusual sight, hearing or sense of smell ~familiar things strange and unusual	0.13
People doing things to annoy me ~ others watching me	0.12
	Fit indices
CFI	0.96
TLI	0.95
RMSEA	0.05
RMSEA.CI.LOWER	0.04
RMSEA.CI.UPPER	0.05
SRMR	0.09

Note. CFI – Comparative Fit Index. TLI – Tucker Lewis index. RMSEA – Root Mean Square Error of Approximation. SRMR – Standardized Root Mean Square Residual.

variables (within-person, daily fluctuations in dream emotions, PLEs, and mood), as well as the interactions between trait-like and state-like variables.

2.4.4. Predicting daytime PLE from previous night's dream emotions

In order to evaluate the temporal association between dream emotions assessed in the morning and PLEs reported during the day, daily scores of PLEs were set as the outcome variables, and latent schizotypy scores, and (previous night's) *positive valence* and the *salience/intensity* of dreaming, and the interactions between valence and salience of dreaming vs. schizotypy were entered as predictors. In case of the day-to-day predictors (dream emotions), the fixed effects of individual means (averaged across the daily reports of the three-week study period, reflecting associations at the between-participant level) and within-person centered scores (reflecting within-person associations) were also entered. PLE scores were log10-transformed, as residual histograms indicated that the normality assumption of residuals was violated when the untransformed PLE-score was the dependent variable. Temporal dependency in PLE-scores was controlled for by explicitly modelling the effect of PLE on the preceding day (autocorrelation). To account for the nested structure of the data, all models included random intercept per participant. Moreover, a random slope was added for the effect PLE on the preceding day (autocorrelation) and the effects of dream valence and salience/intensity. If a model failed to converge, we removed the random slope for autocorrelation and re-fitted the model.

2.4.5. Predicting dream emotions from previous day's PLEs

In order to examine the temporal associations between PLEs reported in the evening and dream emotions the following night, *positive valence* and *salience/intensity* of dreaming were used as two separate outcome

variables. Again, we included schizotypal traits, the within-person overall means of PLEs and mood, as well as the within-person daily fluctuations of previous day's PLEs and mood, and the interactions between daily fluctuations vs. schizotypy. Due to the relatively lower number of dream recall (and hence missing data for dream valence and salience/intensity scores) autocorrelation was not considered in these models. To account for the nested structure of the data, all models included random intercept per participant. Moreover, a random slope was added for the effect of within-person change in PLE and mood. If a model failed to converge, the random slope was removed. In models including within-person change both in PLE and mood, a random slope was added only for within-person change in PLE. Due to the shorter time span between the evening and the following morning, we focused on the models predicting dream emotions from PLEs reported in the previous day's evening. (The models predicting dream emotions from PLEs reported in the previous day's afternoon are reported in the Supplement).

3. Results

3.1. Dream emotions do not predict daytime PLEs

Dream emotions (*positive valence* and *salience/intensity*) or their interaction with trait schizotypy did not predict daytime PLEs measured in the afternoon or in the evening hours. More specifically, no associations emerged between dream emotions or sleep quality and PLEs neither across nor within the participants. That is, inter-individual differences in dream emotions were not associated with inter-individual differences in PLEs, and day-to-day changes in dream emotions were not predictive of next day's PLEs. The same pattern was seen for the association between sleep quality and next day's PLEs. Variation across individuals in PLEs (as measured during the 3 week period) was however related to trait-like factors of *Unusual Experiences* (positive schizotypy) and *General-Disorganized Schizotypy*. Fig. 2. shows the standardized coefficients of the relevant predictors averaged across the models predicting PLEs.

3.2. PLEs in the evening predict dream emotionality

In contrast to PLEs, the emotional quality of dreams was associated with a number of trait-like and state-like variables (Fig. 3). First, relatively increased PLEs in the evening were followed by reduced positive valence of dream emotions the following night. Furthermore, across individuals, negative and general-disorganized schizotypy, cognitive disorganization, and a higher average level of PLEs predicted less positive valence of dream emotions, while positive schizotypy (Unusual Experiences) predicted more positive dream emotionality, albeit rather weakly. Finally, although positive mood in the evening predicted slightly increased positive valence of dreams, the negative effect of PLEs in the evening was much more pronounced. An interaction indicated that the positive effect of mood in the evening on subsequent dream valence was reduced in participants with higher positive schizotypy. And even more importantly, the average of daytime mood ratings during the day was not predictive of dream valence, suggesting that it is unlikely that our findings regarding dream valence are due to response tendencies.

Additionally, we identified factors associated with the salience/intensity of dream emotions. Importantly, PLEs in the evening predicted more salient, emotionally intense dreams of the following night. Positive mood in the evening also predicted increased dream salience and the size of the effect was comparable to that of PLEs. Better mood on average was also related to more salient dreams. Finally, positive schizotypy predicted more salient dream emotions on average, while cognitive disorganization was linked to reduced salience of dream emotions.
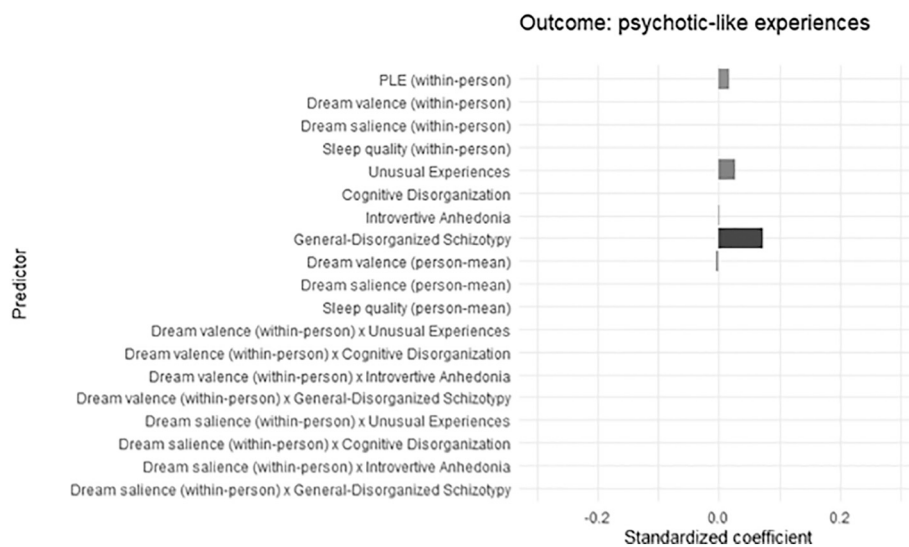
Fig. 2. The effect of dream emotionality on psychotic-like experiences (PLE) the following day.
Note. Standardized coefficient estimates obtained with AICc-weighted model averaging of partially standardized coefficient estimates from 2072 models, using the 'full average' approach (see details in text). For a detailed description of model averaging, see Section 2.4.2. PLE: psychotic-like experiences; 'person-mean': each participant has a single average, so these estimates indicate between-person differences; 'within-person': indicates the deviation from the typical value of the participant, thus, these estimates reflect within-person effects.
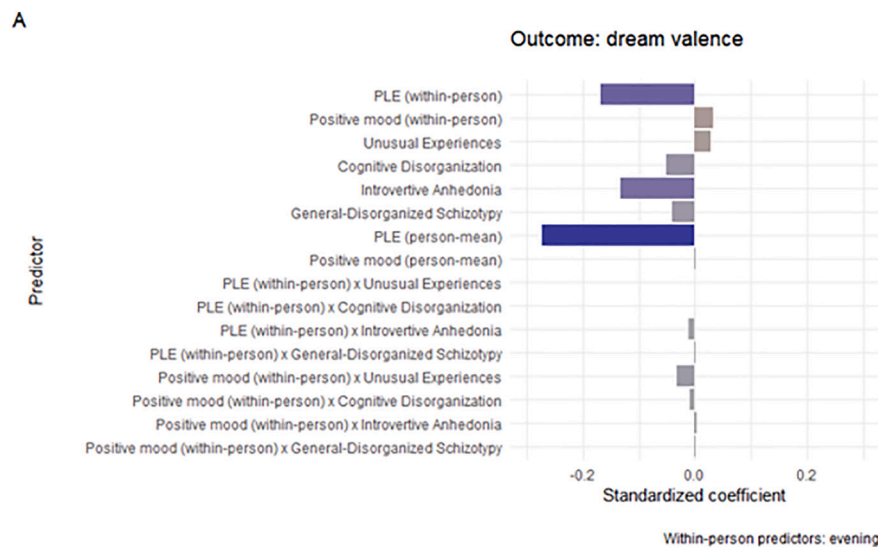

Fig. 3. The effect of dream emotionality on psychotic-like experiences (PLE) the following day.
Note. Standardized coefficient estimates obtained with AICc-weighted model averaging of partially standardized coefficient estimates from 2840 models, using the 'full average' approach (see details in text). For a detailed description of model averaging, see Section 2.4.2. PLE: psychotic-like experiences; 'person-mean': each participant has a single average, so these estimates indicate between-person differences; 'within-person': indicates the deviation from the typical value of the participant, thus, these estimates reflect within-person effects.
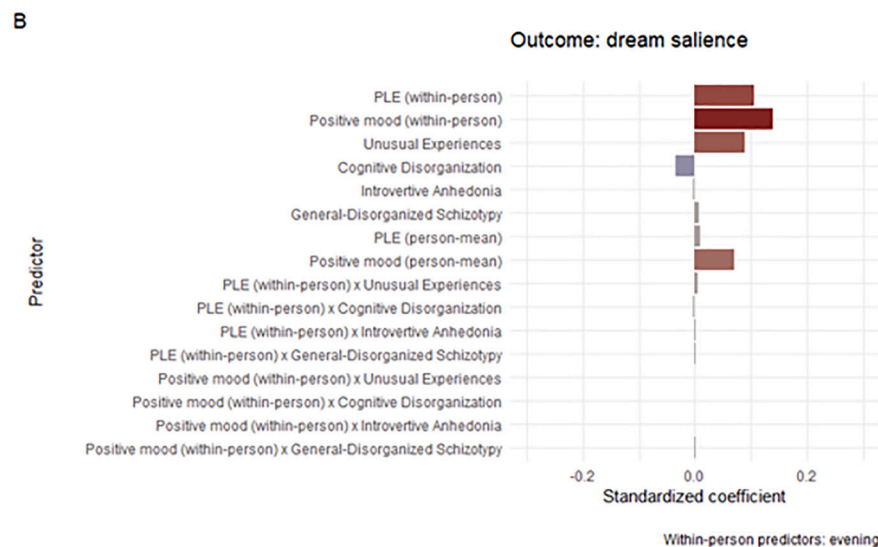
4. Discussion

The aim of the present study was to examine the temporal, day-to-day associations between psychotic-like experiences (PLEs) and the emotional quality of dreams taking into account the influence of schizotypal personality traits. Based on prospective data from 55 young adults who completed daily surveys for three-weeks, we observed a unidirectional association between PLEs and dream reports: PLEs reported in the evening predicted more negative and salient dream reports the following morning. In contrast, the quality of dreams reported in the morning were not predictive of PLEs reported later during the day. Furthermore, schizotypal personality traits showed a specific pattern of associations with dream emotionality. Latent scores reflecting Introvertive Anhedonia (negative schizotypy), Cognitive Disorganization, and General-Disorganized schizotypy were linked to more negative dream emotions. On the other hand, the salience (intensity) of dream emotions was associated with Unusual Experiences (positive schizotypy).

The intimate relationship between dreaming and psychosis was capturing the attention of scholars and artists many years before their systematic scientific investigation. Alfred Maury highlighted the phenomenological similarities between 'insanity' and dreaming in the nineteenth century (Maury, 1878), and their functional similarities were also assumed among the very first ideas of the psychoanalytic tradition (see Gottesman(Gottesmann, 2010) for a review). Likewise, the analogy between the threatening, single-minded nature of nightmares and the malevolent aspects of psychosis (e.g. paranoia), or the presence of unusual, dream-like experiences in positive schizotypy has inspired artists from the antiquity to modern popular culture (Bulkeley, 2010; Schrage-Früh, 2016).

Recent studies indicate that nightmare disorder is the second most prevalent sleep complaint (after insomnia) in patients with psychotic disorders (Waite et al., 2020). Yet, studies focusing on the longitudinal links or temporal associations between these experiences are scarce. Importantly, only prospective studies can reliably inform us about the moment-to-moment fluctuations of, and interrelations between transient, subtle subjective phenomena (such as PLEs and dream experiences). Interestingly, previous prospective studies of dream emotions had focused mainly on daytime emotional experiences, yielding mixed results (Samson-Daoust et al., 2019; Schredl and Reinhard, 2010; Soffer-Dudek and Shahar, 2011). Whereas dream emotions are usually measured by single items or only the presence or absence of nightmares are assessed (Blagrove and Fisher, 2009; Samson-Daoust et al., 2019), in this study, we asked participants to rate the intensity of a wide array of negative and positive emotions, and by applying a principal component analysis, we obtained two dimensions of dream emotionality: valence and salience. Whereas the former clearly reflects the unpleasantness-pleasantness dimension of dream emotions, the interpretation of the second component is less straightforward. Since all of the dream emotions exhibited positive loadings on the second factor, with Curiosity and Surprise showing the highest factor loadings, the component was termed as salience, reflecting the intensity of dream emotions.

Our findings indicate that various psychotic-like features are distinctly associated with the valence and salience of dream emotions. Introvertive Anhedonia, Cognitive Disorganization, and General-Disorganized schizotypy predicted negatively valenced dream emotions. These results align with previous findings showing the association between psychotic symptoms and nightmares (the most intense expression of unpleasant dreaming) (Akkaoui et al., 2020; Akram et al., 2020; Reeve et al., 2019; Sheaves et al., 2015), and suggest that negative schizotypy and cognitive disorganization especially contribute to these links. Dreams often depict socially demanding situations and dream emotions usually arise in a (dreamt) social context, involving a variety of intense social interactions (Tuominen et al., 2019). Highlighting the predominantly social context of dreams, the Social Simulation Theory (Revonsuo et al., 2015) proposes that dreaming serves an adaptive function in rehearsing social interactions and hence, preparing the individuals for social encounters. In this context, negative dream emotions might not be necessarily dysfunctional, but may reflect an effort to simulate socially demanding and threatening situations (Revonsuo, 2000; Revonsuo et al., 2015). Alternatively, the links between schizotypal traits and dream affect may simply reflect the continuity between waking and dream experiences (Schredl, 2003). For instance, paralleling our findings, in daily life, negative schizotypy predicts increased negative and decreased positive affect, and lack of interest in social interactions (Kwapil et al., 2020). Impaired representation of anticipated rewards might underlie these alterations(Cai et al., 2019). Negative schizotypal traits might reduce pleasurable social experiences, facilitate withdrawal, and lower positive affect in dream emotions. Moreover, emotional dysregulation is considered to be a key factor in the occurrence and formation of nightmares (Levin and Nielsen, 2007; T. Nielsen and Carr, 2017) . Relatedly, disorganized schizotypy is related to various indicators of emotional dysregulation, such as increased emotionality and emotional confusion (Kerns, 2006), and increased negative and decreased positive affect in daily life (Kwapil et al., 2020). Our results suggest that in highly disorganized individuals, the failure to regulate negative emotions leaves its mark on dream experiences as well.

In contrast to dream valence, the salience of dream emotions was principally linked to the dimension of positive schizotypy. The association of positive schizotypy with dream salience can be interpreted in the context of creativity. The dream salience dimension in our study was dominated by epistemic emotions (i.e. curiosity and surprise) that have been shown to drive cognitive exploration (Vogl et al., 2019), that is, the search for novel patterns in perception and memory(DeYoung, 2013), that are key steps of the creative process (Amabile, 1983). Relatedly, positive schizotypy is characterized by aberrant cognitive exploration such as an increased tendency to perceive meaning in random stimuli (Blain et al., 2020), and also by increased creativity (Acar and Sen, 2013). Our findings suggest that positive schizotypy is associated with the recombination of representations and exploration of novel patterns not only while individuals are awake, but also during dreaming. Future studies should investigate whether individuals high in positive schizotypy translate these emotionally salient, explorative dream experiences into increased real life creativity (Polner et al., 2018).

PLEs and dream emotions were also associated at the within-individual level. PLEs experienced in the evening hours were followed by emotionally more negative and more salient dream reports the following morning. The temporal association between PLEs and negative dream valence may indicate the emotional load related to impared self-regulation (Akram et al., 2020) . On the other hand, the salience/intensity of dream emotions was also predicted by PLEs the night before, as well as by positive mood (across and within individuals), providing putative links between the more benevolent, creative aspects of PLEs and dream experiences. Our findings are in line with the models suggesting that dysphoric dreaming is predicted by both dispositional and state-like factors (Levin et al., 2011; Levin and Nielsen, 2009, 2007). More specifically, Levin and Nielsen (2007) proposed that dysphoric dreaming is a function of affect distress and affect load, the former being a dispositional (trait-like) factor reflecting generally dysfunctional emotional regulation, and the latter corresponding to transient emotional load. Our results are in line with this framework as dream emotions were both predicted by dispositional schizotypal traits and by psychotic-like experiences as measured the night before sleep. Whereas these links between daytime and oneiric mental phenomena reflect an adaptive process of emotional regulation or are simply highlighting the continuity between wakefulness and dreaming (Schredl, 2006) is a question of future research.

The lack of the effect of subjective sleep quality on the following days' PLEs is inconsistent with previous studies (Hennig et al., 2019; Kasanova et al., 2020; Simor et al., 2019). This might be explained by methodological issues: these previous studies investigated sleep quality with multi-item questionnaires, while here we had a single-item

assessment of sleep quality, which can be expected to have lower reliability.

Our study is not without limitations. First, the generalizability of the findings is to be further tested as we examined a sample of healthy university students (75% female and highly educated) with high dream-recall frequency. Furthermore, daytime mood was assessed with a single item, which did not allow a fine-grained evaluation of associations with mood during wakefulness. Finally, both PLEs and negative, salient dreams can be caused by exposure to stressors (Chun et al., 2020; Klippel et al., 2017) and/or using drugs (Verdoux et al., 2003) and none of these were measured in the present study.

In sum, our study provides novel data linking dispositional and state-like schizotypy with dream experiences, taking into consideration the multidimensional nature of schizotypal traits and dream emotions. Prospective collection of dream reports, and temporal associations between peculiar experiences during the day and the night may shed more light on the underlying mechanisms of psychotic-like phenomena. Moreover, understanding the temporal dynamics between daytime PLEs and oneiric experiences in healthy and/or high-risk individuals can help to identify and target factors that may lead to the onset or relapse of psychosis in pathological conditions.

Contributors

Each of the authors has substantially contributed to this research and drafting the manuscript. The authors have no conflict of interest.

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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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.2022.05.020.

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