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*Published in:*  
Schizophrenia Research

*DOI:*  
[10.1016/j.schres.2023.10.012](https://doi.org/10.1016/j.schres.2023.10.012)

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*  
Publisher's PDF, also known as Version of record

*Publication date:*  
2023

[Link to publication in University of Groningen/UMCG research database](#)

### *Citation for published version (APA):*

Steenhuis, L. A., Harms, T., Nauta, M. H., Bartels-Velthuis, A. A., Albers, C. J., Aleman, A., Vos, M., Pijnenborg, G. H. M., van den Berg, D., Palstra, E. C., Wigman, J. T. W., & Booij, S. H. (2023). The dynamics of social activation and suspiciousness in individuals at ultra-high risk for psychosis. *Schizophrenia Research*, 262, 67-75. <https://doi.org/10.1016/j.schres.2023.10.012>

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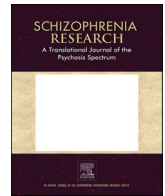
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## Schizophrenia Research

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## The dynamics of social activation and suspiciousness in individuals at ultra-high risk for psychosis

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## ARTICLE INFO

## Keywords:

Psychosis  
Social support  
Risk factors  
Psychopathology  
Suspiciousness

## ABSTRACT

**Introduction:** Social functioning is often impaired during the ultra-high risk (UHR) phase for psychosis, but group-level studies regarding the role of social functioning in transition to psychosis are inconsistent. Exploring the inter-individual differences which underlie the association between social functioning and psychotic symptoms in this phase could yield new insights.

**Objective:** To examine the idiographic and dynamic association between social activation and suspiciousness in individuals at UHR for psychosis using time-series analysis.

**Methods:** Twenty individuals at UHR for psychosis completed a diary application every evening for 90 days. Two items on social activation (quantity: 'time spent alone' and quality: 'feeling supported') and two items on suspiciousness ('feeling suspicious' and 'feeling disliked') were used. Time series (T = 90) of each individual were analyzed using vector auto regression analysis (VAR), to estimate the lagged (over 1 day) effect of social activation on suspiciousness, and vice versa, as well as their contemporaneous associations.

**Results:** Heterogeneous person-specific associations between social activation and suspiciousness were found in terms of strength, direction and temporal aspects.

**Conclusions:** The association between social activation and suspiciousness differs amongst individuals who are at UHR for psychosis. These findings underline the importance of tailoring psychosocial interventions to the individual. Future studies may examine whether using results of single-subject studies in clinical practice to personalize treatment goals leads to better treatment outcomes.

### 1. Introduction

Social functioning is commonly impaired in individuals diagnosed with a psychotic disorder, both in early and more chronic phases

(Addington et al., 2008; Couture et al., 2006). Already before onset of a first psychotic episode, social functioning is impaired (Addington et al., 2008; Ballon et al., 2007), as it is a required criterion to meet the ultra-high risk (UHR) profile for psychosis. Importantly, social functioning

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<https://doi.org/10.1016/j.schres.2023.10.012>

Received 30 September 2022; Received in revised form 25 April 2023; Accepted 18 October 2023

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during this UHR phase was found to be predictive of transition to a psychotic episode (Addington et al., 2017; Cannon et al., 2008; Cornblatt et al., 2007, 2012; Jang et al., 2011). However, the exact nature of the association between social functioning and the development of psychosis is complex, and the evidence regarding how social functioning predicts the onset of a first psychotic episode is not always consistent (Brandizzi et al., 2015). To specify, a substantial number of individuals in UHR samples demonstrate social impairments that persist over time without transitioning to psychosis, whilst other individuals in UHR samples with less social impairments do transition to psychosis (Brandizzi et al., 2015; Yung et al., 2010). Deficits in social functioning during the UHR phase are also associated with other symptoms, such as negative symptoms (Carrión et al., 2011; Kim et al., 2013; Lee et al., 2017; Schlosser et al., 2015), impaired emotional awareness (Kimhy et al., 2016) and cognitive deficits (Carrión et al., 2021). Even though it is clear that social functioning should be a target for intervening during the UHR phase, current interventions do not effectively alleviate the social impairment in this early phase (Devoe et al., 2019; van der Gaag et al., 2019). Exploring the inter-individual differences underlying the association between social functioning and psychotic symptoms in the UHR phase of psychosis, could yield new insights for clinical practice.

Studies using experience sampling methodology (ESM; Myin-Germeys et al., 2018) in which participants self-report on their experiences in daily life for a prolonged period of time, show that different aspects of social functioning and social context can have a varying (and sometimes contradicting) impact on the expression of psychotic symptoms in psychotic disorders (Delespaul et al., 2002; Verdoux et al., 2003). One of the first ESM studies (Delespaul et al., 2002) demonstrated that in patients with a psychotic disorder, social withdrawal and inactivity may actually be beneficial for decreasing the intensity of hallucinations, whereas social engagement can raise this hallucinatory intensity. In contrast, a different study (Myin-Germeys et al., 2001) in patients with a psychotic disorder demonstrated that the presence of family members or friends is protective for delusional experiences, whereas social withdrawal makes these more likely to occur. More recent research in individuals at UHR for psychosis demonstrated that minor interpersonal stress in daily life is associated with the intensity of psychotic experiences, which varies according to the severity of childhood sexual trauma (Reininghaus et al., 2016). Overall, these studies further support the notion that social functioning is a dynamic and multifaceted concept, and that the association between psychotic symptoms and social functioning in psychotic disorders is possibly person-specific.

Existing ESM studies often use multilevel analysis, which incorporate inter-individual fluctuations and between-subject differences, but still average individual regression coefficients for all participants (Zuidersma et al., 2020). When longitudinally collected data is intensive (i.e., many time points per individual), this allows for the application of within-subject time-series analyses. Such techniques are optimally suitable to explore heterogeneity between individuals, in particular to estimate bidirectional associations separately for each individual and thus to investigate whether and how the direction of an association can differ within individuals. Using such an approach, all variables can be modelled as both predictors and outcomes for each person individually (Brandt and Williams, 2007). The question of how social functioning is associated with psychotic experiences in the UHR phase could benefit from such an approach, as it could reveal unique insights regarding the UHR for psychosis state specifically because it can provide more insight in between-person heterogeneity, which might have important implications for clinical interventions.

Although previous ESM studies have examined psychotic symptoms such as hallucinations (Delespaul et al., 2002) or delusions (Myin-Germeys et al., 2001) in patients with psychotic disorders, the current study will assess mild psychotic experiences, specifically suspiciousness. Given that suspiciousness is a psychotic experience commonly present before the first psychotic episode (An et al., 2010; Cannon et al., 2008) and frequently reported on a daily basis in UHR patients (Yung et al., 2003),

it is a suitable measure for the daily assessment of psychotic experiences in this sample. In addition, given the interpersonal nature of suspiciousness as a psychotic experience, it might have an especially relevant association with social functioning. In line with previous studies (Delespaul et al., 2002; Myin-Germeys et al., 2001), the current study will assess daily social activation as a proxy for overall daily social functioning. Assessing both the quantity ('amount of time spent alone') and quality ('feeling supported') of social activation matches the multifaceted nature of social functioning as a global construct.

The current study will examine the association between social activation and suspiciousness in depth in a sample of twenty individuals at UHR for psychosis over a period of 90 days, exploring for each individual separately the directionality and temporal dynamics of this association. The current study is explorative and therefore no explicit hypotheses are made regarding the type and direction of the association within individuals. In line with previous daily sampling studies, it is expected that the association between social activation and suspiciousness will be heterogeneous and person-specific.

## 2. Materials and methods

### 2.1. Participants and procedure

For the current study, the association between social activation and suspiciousness was examined in twenty individuals at ultra-high risk (UHR) for psychosis. Participants were part of the UHR subgroup of the Mapping Individual Routes of Risk and Resilience (MIRORR) study, a 90-day diary study of mental symptoms, stress and experiences in individuals at different levels of risk for psychosis. For detailed information about the MIRORR study and recruitment of the subgroups, see the study protocol (Booij et al., 2018).

For the current study, participants were recruited at mental health care facilities in the Netherlands, where they received treatment for a non-psychotic psychiatric disorder. The treatment consisted of cognitive behavioural therapy and/or medication for the diagnosis participants were in treatment, in line with evidence-based treatment recommendations and tailored to the personal wishes of the client. In addition, once participants were identified as being at UHR for psychosis, they were offered add-on treatment for this (see also CBT for the prevention of psychosis; van der Gaag et al., 2019), but not all participants agreed nor started this treatment at the time that the research study commenced.

The following inclusion criteria were adhered to: (1) aged between 18 and 35 years, (2) read and speak Dutch fluently, (3) capable of following the research procedures, (4) provide informed consent and (5) meeting the criteria for UHR status. UHR status was assessed using, first, the Prodromal Questionnaire-16 items (PQ-16; Ising et al., 2012) and, if participants scored  $\geq 6$ , subsequently the CAARMS interview (Comprehensive Assessment of At-Risk Mental States; Yung et al., 2005). UHR status was confirmed if one of three criteria were met as determined by the CAARMS: (i) a familial risk, (ii) brief limited intermittent psychotic symptoms (BLIPS) or (iii) attenuated positive symptoms (APS). In addition, a significant social impairment as assessed with the Social and Occupational Functioning Scale (SOFAS; Goldman et al., 1992) had to be present. Exclusion criteria consisted of: (1) a history of or current psychotic episode (according to the DSM-4 criteria), (2) significant hearing or visual impairments and (3) pregnancy. Note that, on the basis of the clinical staging model of psychosis (McGorry et al., 2006), all participants were already in treatment for mental health problems and thus the presence of other non-psychotic disorders was not an exclusion criteria.

Interested participants received a package with information on the study, screening questionnaires, and an informed consent form. After providing written informed consent, participants were assessed with the mini-SCAN (Nienhuis et al., 2010), and received information on the daily diary procedure. All participants received a personal report of their

diary results and a financial compensation. The study was conducted according to the World Medical Association Declaration of Helsinki, and approved by the Medical Ethical Committee of the University Medical Center Groningen (ABR no. NL52974.042.15).

## 2.2. Diary assessment application

Participants completed the diary assessment application online on their smartphone once a day for 90 days. The application generated a text message containing a link to the complete online diary questionnaires every evening (see study protocol (Booij et al., 2018)). One assessment moment per day (i.e. the evening) was chosen in order to capture the average experiences over one day for longer period of time, without sampling too often. Participants had a time window of 1.5 h to complete the diary. It took on average 7 min to complete the diary assessment.

## 2.3. Measures

### 2.3.1. Baseline assessment

The Comprehensive Assessment of At-Risk Mental States (CAARMS; Yung et al., 2005) and the Social and Occupational Functioning Scale (SOFAS; Goldman et al., 1992) were used to determine the presence of an UHR state. The mini-SCAN (Nienhuis et al., 2010) was used to assess and confirm the presence of psychiatric disorders. The Community Assessment of Psychic Experiences (CAPE (Konings et al., 2006) was utilized to assess the frequency and distress of positive psychotic experiences.

### 2.3.2. Dairy items

For the current study, two items assessing suspiciousness and two items assessing social activation (four items total) were utilized. Other items assessing psychotic experiences or social context which were included in the daily diary were not utilized in the current study, as these were not suitable for the research question or the planned time-series analyses. For example, hallucinations were not reported frequently in this sample, nor did they fluctuate from day to day. In addition, items covering social situations were conditional on other items in the daily diary, rendering them unfit for the planned analyses. As such, the four chosen items were selected on the basis of both theoretical as well as methodological reasons.

Suspiciousness was assessed in ways similar to previous dairy studies (Myin-Germeys et al., 2005; Oorschot et al., 2009; Wigman et al., 2013) on a VAS-scale (from 'not at all' 0 to 'very' 100). The items were "I felt suspicious today" and "Today I had the feeling that others did not like me". Social activation was assessed as the quantity of social contacts on a given day, scored on a 7-point Likert scale ("How much was I alone today", ranging from 1 'not at all' to 7 'all day') and as the quality of social contacts on a given day, scored on a VAS scale ("Did you feel supported today?" from 0 'not at all' to 100 'very').

## 2.4. Statistical analysis

Vector autoregressive (VAR) modeling was used to analyze the multiple time series of each individual in this study. VAR modeling allows the modeling of a set of regression equations for two or more variables, in this case consisting of social activation (1. time spent alone and 2. feeling supported) and paranoid psychotic experiences (1. feeling suspicious and 2. feeling disliked). All four variables in this model could be both determinant and outcome, allowing the temporal order of effects to be tested, including bidirectional associations and feedback loops. For associations between variables at the same time point on the same day, contemporaneous correlations were assessed from the residuals of the VAR models. For time-lagged associations, each variable was regressed on its own lagged value (e.g.  $t - 1$ ) and the lagged values of the other variables. The number of lags in this model was a priori set to one,

equivalent to a period of one day. The lagged effect is indicative of a delayed effect of the past day's social activation on current psychotic experiences over time (and vice versa for the opposite effect). Granger causality Wald tests (Granger, 1969) were used to test the significance of the directionality of the influence between two time series. To meet the assumptions of VAR models (stationarity, normality, homoscedasticity and independence of the residuals (i.e. white noise)), some preprocessing steps were taken for the whole sample (e.g. smoothing of the time-series to render all series stationary), and some modeling steps were taken for specific individuals when necessary (e.g. adding a higher lag as predictor to remove residual autocorrelation). Missing values were imputed using the exponential moving average method with the TS package (van der Tuin et al., 2021). For more details about assumption checks and imputation, please see the supplementary file. Analyses were computed in STATA 15 using the suite of VAR commands (StataCorp, 2017).

## 3. Results

### 3.1. Descriptives

The 20 participants at UHR for psychosis were on average 24.0 (SD 4.7) years old and 15 % ( $n = 3$ ) were males. Besides meeting UHR for psychosis criteria, participants had a primary diagnosis of a depressive disorder (90 %), a specific phobia (5 %) or did not meet any DSM criteria (5 %). Comorbid disorders were present in all but the one participant who did not meet any diagnostic criteria ( $n = 19$ , 95 %). Of those participants, 12 had three more or more diagnoses (60 %) and eight had four or more diagnoses (40 %). Participants had an average score of 24.6 (SD 4.4) on frequency of positive symptoms of the CAPE and 7.4 (SD 7.7) on distress of positive symptoms of the CAPE. After one year, 3 (15 %) participants transitioned to a first psychotic episode. In Table 1 descriptive statistics for each participant, and assumptions for each item, can be found.

For a large number of participants, the stationarity assumption was not met initially (see Table 1). In addition, some items were correlated with time, indicating they naturally increase or decrease over time. For example, for participant 6 'time spent alone' had a moderate negative correlation with time ( $r = -0.32$ ), indicating that 'time spent alone' had a decreasing trend over time. This is important to take into account when interpreting subsequent analyses of the data. Including a linear or quadratic trend was not sufficient to remove non-stationarity for most participants, suggesting more complex forms of non-stationarity. For this reason, the data of all participants was corrected using a lowess smoothing function. Participant 5 was removed from the analysis as the heteroscedasticity assumption was violated and could not be corrected, leaving  $n = 19$  in our final sample. For participants 3, 9, 14 and 16 the item 'time spent alone' had little variability over time and could not be entered in subsequent analyses.

### 3.2. Contemporaneous associations between social activation and suspiciousness

In Table 2, contemporaneous (within-day) associations between social activation and suspiciousness are displayed. The strongest absolute associations were found for the contemporaneous association between 'feeling disliked' and 'feeling supported' (mean  $r$ : 0.22). Around half of the participants ( $n = 10$ , 53 %) had a significant negative contemporaneous correlation between these two items within the same day. The second strongest absolute associations were found for the contemporaneous association between 'feeling suspicious and 'feeling supported' (mean  $r$ : 0.16). For almost all participants ( $n = 18$ , 95%) this association was negative. The third strongest absolute associations were found for the contemporaneous association between 'feeling suspicious and 'time spent alone' (mean  $r$ : 0.14). A small majority of participants had positive associations ( $n = 9$ , 60 %). The weakest absolute associations were

**Table 1**  
Average values and assumptions per item for each participant.

	Social activation							Suspiciousness								
	Time spent alone				Feeling supported			Feeling suspicious			Feeling disliked					
	Stationarity		Trend with time	Mean (SD)*	Stationarity		Trend with time	Mean (SD)	Stationarity		Trend with time	Mean (SD)	Stationarity		Trend with time	Mean (SD)
	ADF	KPSS			ADF	KPSS			ADF	KPSS			ADF	KPSS		
1	Yes	Yes	0.24	4.05 (1.18)	No	Yes	-0.16	14.31 (18.84)	Yes	Yes	0.15	28.71 (19.90)	Yes	Yes	0.07	16.55 (11.34)
2	No	Yes	-0.14	2.97 (2.05)	Yes	Yes	0.17	9.31 (25.12)	No	Yes	0.08	28.89 (17.54)	No	Yes	-0.07	24.27 (20.64)
3	Yes	Yes	0.15	1.43 (0.77)	No	No	0.36	18.91 (15.09)	Yes	No	-0.30	17.71 (5.64)	Yes	Yes	-0.10	15.09 (4.74)
4	Yes	Yes	0.17	3.58 (2.14)	Yes	Yes	-0.09	6.95 (23.73)	No	Yes	0.07	21.04 (20.87)	Yes	Yes	0.02	17.42 (20.12)
5	Yes	Yes	-0.13	2.24 (1.48)	Yes	No	0.52	39.17 (11.36)	Yes	No	-0.73	14.64 (12.28)	Yes	No	-0.70	7.18 (5.33)
6	Yes	No	-0.32	2.72 (1.08)	Yes	No	0.33	21.87 (21.11)	Yes	Yes	0.01	43.77 (25.36)	Yes	Yes	-0.16	51.29 (23.11)
7	No	Yes	0.07	4.10 (1.89)	No	Yes	0.02	25.31 (30.31)	No	Yes	-0.07	55.20 (26.36)	No	No	-0.19	50.67 (29.45)
8	No	No	0.28	3.62 (0.84)	Yes	No	-0.27	16.58 (19.28)	No	Yes	0.00	45.90 (17.19)	Yes	Yes	0.22	54.48 (19.34)
9	Yes	No	0.44	1.56 (0.79)	Yes	No	-0.25	42.82 (21.58)	Yes	Yes	-0.21	25.95 (14.11)	Yes	Yes	-0.14	14.97 (13.84)
10	Yes	Yes	-0.18	2.27 (1.46)	Yes	Yes	0.15	41.83 (22.38)	Yes	Yes	0.01	22.16 (25.89)	Yes	Yes	-0.21	19.29 (22.32)
11	No	Yes	0.16	3.84 (1.73)	Yes	Yes	-0.23	35.26 (20.19)	Yes	Yes	0.16	42.39 (18.57)	Yes	Yes	0.08	49.09 (14.50)
12	No	Yes	0.08	2.69 (1.44)	Yes	Yes	0.12	9.08 (19.91)	Yes	Yes	0.15	59.69 (15.74)	Yes	Yes	0.01	50.06 (13.84)
13	Yes	No	0.31	3.56 (1.77)	Yes	Yes	-0.14	20.41 (8.35)	No	No	0.25	33.03 (13.10)	No	No	-0.50	17.00 (10.06)
14	Yes	No	-0.30	1.27 (0.77)	No	No	-0.45	39.74 (15.61)	Yes	Yes	-0.22	30.08 (14.62)	Yes	Yes	-0.16	33.99 (18.46)
15	Yes	No	0.24	2.77 (1.54)	Yes	Yes	-0.19	25.79 (19.40)	No	No	0.36	36.62 (20.21)	Yes	Yes	0.06	38.36 (16.61)
16	Yes	No	-0.27	1.15 (0.57)	No	Yes	-0.03	14.71 (23.30)	Yes	No	-0.42	7.84 (13.17)	Yes	No	-0.36	7.90 (12.02)
17	Yes	No	0.11	3.81 (1.66)	No	Yes	-0.29	42.31 (30.99)	No	Yes	-0.09	31.90 (26.99)	Yes	NoNo	0.03	14.60 (17.84)
18	No	No	-0.22	3.85 (1.82)	Yes	Yes	-0.12	27.23 (15.84)	No	No	0.38	10.33 (13.43)	Yes	No	-0.49	6.82 (6.97)
19	Yes	No	-0.29	2.12 (0.72)	Yes	Yes	-0.01	27.35 (14.12)	Yes	Yes	-0.08	12.52 (13.09)	No	Yes	-0.26	25.57 (19.01)
20	Yes	Yes	-0.22	4.31 (1.55)	Yes	Yes	0.00	74.24 (35.50)	Yes	No	0.35	59.55 (28.76)	Yes	Yes	0.07	27.32 (27.61)

Note. ADF, Augmented Dickey-Fuller test; KPSS, Kwiatkowski-Phillips-Schmidt-Shin test; Yes indicates the stationarity assumption is met according to that test, whereas No indicates the stationarity assumption is violated according to that test.

\* The original scale from 1 to 7 was used to compute the descriptive statistics.

found for the contemporaneous association between ‘feeling disliked’ and ‘time spent alone’ with a mean correlation of 0.09, which was only significant for one participant. The sign of this association differed between participants, as roughly half report a negative association (n = 8, 53 %), whilst the remaining reported a positive association (n = 7, 47 %).

### 3.3. Lagged associations between social activation and suspiciousness (t - 1)

In Table 3, the lagged effect over a period of one day is shown for social activation on suspiciousness (left side), and suspiciousness on social activation (right side). The lagged associations between social activation and suspiciousness are heterogeneous. For nine out of 19 participants (47 %) there were no lagged associations. For the remainder of participants (n = 10, 53 %), different patterns of effects were found. A significant lagged effect of suspiciousness on social activation was found for five participants, where an increase in suspiciousness was associated with a decrease in social activation the next day (participants 1, 15, 20), or to an increase in social activation the next day (participants 12, 17). A significant lagged effect of social activation on suspiciousness was

determined for six participants, where an increase in social activation was associated with a decrease in suspiciousness the next day (participants 2, 6, 7, 11, 15), and/or to an increase in suspiciousness the next day (participants 7, 11, 14, 15). Interestingly, some participants reported both directions of effects depending on which item was selected. For example, for participant 11 more time spent alone was associated with feeling less suspicious, whilst an increase in feeling supported was associated with feeling less disliked.

## 4. Discussion

The main aim of this study was to explore how the nature of the association between social activation and suspiciousness differs between 20 individuals at UHR for psychosis. This was done by examining the association between daily reports of social activation (quantity ‘time spent alone’ and quality ‘feeling supported’) and suspiciousness (‘feeling disliked’ and ‘feeling suspicious’) over a period of 90 days. It was expected that the association between social activation and suspiciousness would be heterogeneous and person-specific. The findings indeed confirm that the daily association between suspiciousness and social activation manifests itself in different ways during the UHR of psychosis



**Table 2**

Contemporaneous correlations between social activation (time spent alone and feeling supported) and suspiciousness (feeling suspicious and feeling disliked).

	Feeling suspicious				Feeling disliked			
	Time spent alone		Feeling supported		Time spent alone		Feeling supported	
	Participant	Correlation coefficient (95 % C. I.)	Participant	Correlation coefficient (95 % C. I.)	Participant	Correlation coefficient (95 % C. I.)	Participant	Correlation coefficient (95 % C. I.)
	11	-0.25* (-0.43, -0.05)	1	-0.33** (-0.50, -0.13)	11	-0.26* (-0.44, -0.06)	19	-0.48** (-0.63, -0.30)
	15	-0.16 (-0.35, 0.05)	6	-0.32** (-0.49, -0.12)	20	-0.21 (-0.40, 0.00)	13	-0.43** (-0.59, -0.24)
	7	-0.12 (-0.32, 0.09)	13	-0.31** (-0.49, -0.11)	15	-0.18 (-0.37, 0.03)	20	-0.42** (-0.58, -0.23)
	10	-0.11 (-0.31, 0.10)	9	-0.26* (-0.44, -0.06)	19	-0.10 (0.30, 0.11)	4	-0.35** (-0.52, -0.15)
	12	-0.09 (-0.29, 0.11)	19	-0.23* (-0.42, -0.02)	2	-0.06 (-0.26, 0.15)	10	-0.35** (-0.52, -0.15)
	20	-0.09 (-0.29, 0.11)	17	-0.22* (-0.41, -0.01)	4	-0.05 (-0.25, 0.16)	9	-0.31** (-0.49, -0.11)
	8	0.03 (-0.18, 0.24)	10	-0.21 (-0.40, 0.00)	8	-0.05 (-0.25, 0.16)	7	-0.29** (-0.47, -0.09)
	4	0.06 (-0.15, 0.26)	16	-0.20 (-0.39, 0.01)	7	-0.03 (-0.24, 0.18)	1	-0.23* (-0.42, -0.02)
	6	0.07 (-0.14, 0.27)	11	-0.14 (-0.34, 0.07)	18	0.00 (-0.21, 0.21)	3	-0.23* (-0.42, -0.02)
	13	0.09 (-0.12, 0.29)	14	-0.13 (-0.33, 0.08)	1	0.02 (-0.19, 0.23)	15	-0.21 (-0.40, 0.00)
	19	0.12 (-0.09, 0.32)	3	-0.13 (-0.33, 0.08)	17	0.03 (-0.18, 0.24)	16	-0.20 (-0.39, 0.01)
	17	0.15 (-0.06, 0.35)	4	-0.13 (-0.33, 0.08)	10	0.04 (-0.17, 0.25)	14	-0.18 (-0.37, 0.03)
	18	0.21* (0.00, 0.40)	20	-0.13 (-0.33, 0.08)	6	0.11 (-0.10, 0.31)	2	-0.18 (-0.37, 0.03)
	2	0.23* (0.02, 0.42)	2	-0.12 (-0.32, 0.09)	13	0.13 (-0.08, 0.32)	6	-0.13 (-0.33, 0.08)
	1	0.32** (0.12, 0.49)	7	-0.05 (-0.25, 0.16)	12	0.15 (-0.06, 0.35)	17	-0.13 (-0.33, 0.08)
			12	-0.04 (-0.24, 0.17)			12	0.02 (-0.19, 0.23)
			8	-0.02 (-0.23, 0.19)			18	0.01 (-0.20, 0.22)
			15	-0.01 (-0.22, 0.20)			8	0.00 (-0.21, 0.21)
			18	-0.01 (-0.22, 0.20)			11	0.00 (-0.21, 0.21)
Absolute mean strength of correlation	0.14		0.16		0.09		0.22	
Nr. of positive correlations (%)	9 (60 %)		1 (5 %)		7 (47 %)		4 (25 %)	
Nr. of negative correlations (%)	6 (40 %)		18 (95 %)		8 (53 %)		15 (75 %)	

Note. For participants 3, 9, 14, 16 time spent alone could not be entered in the analyses.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

phase, both within days and across days, which may have important implications for clinical practice.

For associations within the same day (contemporaneous associations), the quantity of social activation ('time spent alone') was both positively and negatively associated to suspiciousness ('feeling disliked' and 'feeling suspicious'). Thus, for some individuals the presence of others was associated with enhanced suspiciousness, whilst for others the presence of others was associated with decreased suspiciousness within the same day. This is in line with findings from previous diary studies investigating social constructs and psychotic symptoms in individuals with a psychotic disorder, reporting both positive effects (Delespaul et al., 2002) and negative effects (Myin-Germeys et al., 2001) of social withdrawal on psychotic symptoms. A negative association between enhanced suspiciousness ('feeling disliked' and 'feeling suspicious') and feeling supported, but not with time spent alone, within the same day was demonstrated in the majority of participants. This indicates that on days when participants felt increasingly paranoid, they did not necessarily spend more or less time with others, but they did experience a lower quality of social contact in terms of feeling less supported. This is in line with previous research (Combs et al., 2013) showing that suspiciousness is associated with increased difficulties in social perception during social contact.

Findings from the lagged associations (over a period of one day) also demonstrate heterogeneous and person-specific findings. Previous day changes in suspiciousness were either not associated, positively

associated or negatively associated with social activation on the next day, and vice versa. These results emphasize the heterogeneity of individuals in the UHR of psychosis phase. As such, a universal conclusion on social functioning and its relation to psychotic experiences may be out of place. The heterogeneous findings of this study underline findings that for some a decline in social functioning may not be predictive of a psychotic episode in the presence of impaired social functioning (Brandizzi et al., 2015). However, future studies in larger more generalizable samples that adopt shorter measurement intervals whilst analyzing these at an individual level are needed to draw more firm conclusions on this topic.

Findings from the lagged associations also reveal that for those with an association between lagged suspiciousness and social activation over time (53 % of the sample), this unfolds in different ways for different individuals. For some participants, increases in suspiciousness on a previous day are associated with social withdrawal on the next day, whereas for others this is associated with seeking out more contact the next day. Similarly, findings also demonstrated that increases in social activation on a previous day are associated with decreases in suspiciousness the next day for some individuals, whilst for others they were associated with increases in suspiciousness on the next day. Previous research shows that when (and if) individuals at UHR for psychosis become suspicious in a social situation, they may respond to this suspiciousness with impaired emotion regulation strategies (Lincoln et al., 2018). Perhaps impaired emotion regulation strategies underlie the

**Table 3**  
Lagged effect (t – 1) (social activation t – 1 → suspiciousness t & suspiciousness t – 1 → social activation t).

Participant	Social activation t – 1 → suspiciousness t						Suspiciousness t – 1 → social activation t					
	Outcome: feeling suspicious			Outcome: feeling disliked			Outcome: time spent alone			Outcome: feeling supported		
	Time spent alone	Feeling supported	Auto correlation	Time spent alone	Feeling supported	Auto correlation	Feeling suspicious	Feeling disliked	Auto correlation	Feeling suspicious	Feeling disliked	Auto correlation
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
1	0.08 (0.12)	0.12 (0.12)	0.03 (0.13)	0.00 (0.07)	0.11 (0.07)	0.27 (0.11)	0.30 (0.12)*	0.02 (0.19)	0.15 (0.11)	–0.04 (0.12)	0.08 (0.19)	0.12 (0.12)
2	–0.01 (0.06)	–0.01 (0.07)	0.29 (0.12)	0.12 (0.07) <sup>#</sup>	0.01 (0.08)	0.56 (0.11)**	–0.35 (0.24)	0.15 (0.20)	0.30 (0.12)*	0.20 (0.20)	–0.09 (0.17)	0.10 (0.12)
3	na	0.01 (0.05)	0.09 (0.11)	na	–0.06 (0.04)	0.04 (0.10)	na	na	na	0.03 (0.25)	–0.17 (0.29)	–0.06 (0.11)
4	0.06 (0.07)	0.05 (0.10)	–0.05 (0.12)	–0.08 (0.07)	–0.16 (0.10)	0.02 (0.13)	–0.04 (0.21)	–0.17 (0.22)	0.08 (0.12)	0.05 (0.15)	0.01 (0.15)	0.12 (0.12)
5	na	na	na	na	na	na	na	na	na	na	na	na
6	0.14 (0.16)	–0.22 (0.13) <sup>#</sup>	–0.10 (0.11)	0.19 (0.15)	–0.04 (0.12)	0.24 (0.11)*	0.11 (0.07)	–0.04 (0.08)	0.11 (0.11)	0.07 (0.09)	0.03 (0.10)	–0.04 (0.11)
7	0.00 (0.10)	0.02 (0.11)	0.12 (0.13)	0.22 (0.10)*	0.21 (0.11) <sup>#</sup>	0.08 (0.13)	0.12 (0.18)	–0.20 (0.17)	0.06 (0.14)	–0.01 (0.17)	–0.06 (0.16)	0.09 (0.14)
8	0.05 (0.14)	–0.04 (0.10)	0.01 (0.11)	–0.17 (0.16)	–0.12 (0.12)	0.04 (0.11)	–0.02 (0.08)	–0.08 (0.07)	0.21 (0.10)*	–0.07 (0.11)	0.08 (0.10)	–0.04 (0.11)
9	na	–0.02 (0.07)	–0.20 (0.11)	na	–0.12 (0.07)	0.14 (0.12)	na	na	na	0.07 (0.18)	0.03 (0.18)	0.02 (0.11)
10	–0.02 (0.13)	0.04 (0.15)	0.19 (0.12)	0.08 (0.11)	0.13 (0.13)	0.15 (0.13)	–0.16 (0.11)	0.21 (0.14)	0.06 (0.12)	–0.12 (0.11)	–0.08 (0.14)	–0.05 (0.13)
11	–0.15 (0.07)*	0.04 (0.10)	–0.09 (0.12)	–0.05 (0.06)	–0.17 (0.08)*	0.24 (0.12)	0.06 (0.20)	0.01 (0.25)	0.12 (0.12)	–0.03 (0.14)	0.28 (0.17)	0.12 (0.11)
12	0.09 (0.08)	0.07 (0.09)	0.03 (0.11)	–0.01 (0.07)	0.02 (0.08)	–0.05 (0.11)	–0.16 (0.16)	–0.21 (0.17)	0.22 (0.11)	0.45 (0.13)**	0.13 (0.14)	–0.01 (0.11)
13	0.01 (0.06)	0.01 (0.19)	0.08 (0.11)	0.04 (0.04)	–0.05 (0.13)	–0.06 (0.12)	0.19 (0.21)	0.27 (0.33)	0.27 (0.11)*	0.06 (0.08)	–0.14 (–0.12)	–0.06 (0.13)
14	Na	0.21 (0.12) <sup>#</sup>	0.11 (0.13)	Na	0.25 (0.16)	0.10 (0.13)	na	na	na	–0.10 (0.12)	0.14 (0.09)	0.05 (0.11)
15	0.11 (0.08)	0.19 (0.10) <sup>#</sup>	0.16 (0.11)	0.13 (0.07) <sup>#</sup>	0.10 (0.09)	0.16 (0.11)	–0.16 (0.16)	0.05 (0.16)	0.08 (0.11)	–0.06 (0.12)	–0.21 (0.12) <sup>#</sup>	0.08 (0.11)
16	na	–0.03 (0.06)	–0.26 (0.12)*	na	–0.06 (0.05)	0.18 (0.12)	na	na	na	–0.11 (0.22)	–0.24 (0.23)	0.25 (0.11)*
17	0.05 (0.09)	–0.12 (0.10)	–0.07 (0.12)	0.01 (0.07)	0.08 (0.07)	0.01 (0.11)	–0.03 (0.13)	–0.16 (0.17)	–0.08 (0.11)	–0.07 (0.13)	0.30 (0.16) <sup>#</sup>	0.16 (0.11)
18	0.01 (0.05)	0.05 (0.08)	0.42 (0.10)**	0.03 (0.02)	–0.01 (0.04)	0.48 (0.09)**	0.23 (0.25)	–0.39 (0.46)	–0.04 (0.11)	0.22 (0.14)	0.14 (0.26)	0.05 (0.11)
19	–0.15 (0.12)	0.07 (0.11)	0.11 (0.11)	–0.13 (0.16)	0.12 (0.15)	0.10 (0.13)	–0.06 (0.10)	0.05 (0.08)	0.11 (0.11)	–0.10 (0.12)	–0.08 (0.10)	0.05 (0.13)
20	–0.09 (0.11)	–0.05 (0.09)	0.03 (0.11)	0.06 (0.13)	–0.02 (0.10)	–0.08 (0.13)	0.19 (0.11) <sup>#</sup>	–0.02 (0.11)	–0.11 (0.11)	–0.09 (0.16)	–0.24 (0.16)	0.09 (0.12)
Mean size coefficient	0.07	0.07		0.09	0.10		0.16	0.14		0.10	0.13	
Nr. of positive coefficients	10 (66.6 %)	12 (63 %)		10 (66.6 %)	9 (47 %)		7 (47 %)	7 (47 %)		8 (42 %)	10 (53 %)	
Nr. of negative coefficients	5 (33.3 %)	7 (37 %)		5 (33.3 %)	10 (53 %)		8 (53 %)	8 (53 %)		11 (58 %)	9 (47 %)	

Note. For participant 3, 9, 14, and 16 time spent alone could not be entered (analyses).

<sup>#</sup>  $p < 0.10$ .

\*  $p < 0.05$ .

\*\*  $p < 0.01$

lagged associations between increases in social activation and increases in suspiciousness in our sample. On the contrary, individuals in our sample that do seek out social situations as a response (and possibly coping method) to increasing levels of suspiciousness, may have relatively intact emotion regulation skills which they can implement to regulate their interpretations of social situations. In clinical practice, these individuals may be treated in different ways with preventative cognitive behavioural therapy (CBT), using a formulation driven approach (van der Gaag et al., 2019). For some patients it may be useful to use preventative CBT in combination with strengthening the social network (e.g. using the MOMENTUM intervention as an add-on treatment; Alvarez-Jimenez et al., 2018). For others it may be helpful to facilitate emotion regulation strategies in addition to correcting paranoid thoughts in the context of preventative CBT (Mei et al., 2021; van der Gaag et al., 2019).

Overall, our study showed that individuals at UHR for psychosis demonstrate large heterogeneity in their person-specific associations between suspiciousness and social activation over time. Our results may encourage clinicians to examine per patient how psychopathology is associated with social activation over time. Personalized diary tools, such as the recently developed tool called PETRA (<https://www.petrap sy.nl/en/>), which uses experience sampling methodology in psychiatric care to describe associations (without statistical testing), allow for this. Using such tools, clinicians and patients may gain insight into experiences outside of the therapy room and may guide more effective decisions on the direction of treatment. This can be used in the context of preventative CBT (van der Gaag et al., 2019), to further personalize treatment goals in order to enhance the ability of CBT to effectively target social functioning. However, the use of time-series analyses in clinical practice, like the VAR models we used, may not be recommended (yet) for at least two reasons. First, the temporal (lagged) associations may, but not necessarily do, indicate causal effects (there may be unmeasured common causes), making it difficult to draw firm causal conclusions, especially without all the relevant context taken into account. Unmeasured common causes which fluctuate over time could consist of contextual factors (such as the type of contact or the frequency of contacts on a given day; Delespaul et al., 2002; Myin-Germeys et al., 2005; Verdoux et al., 2003), treatment progress or exposure to stressful events. Moreover, few studies have examined the effects of personalized treatment recommendations based on VAR-based results. For example, a recent study (Van Roekel et al., 2017) found mixed results when they examined the effects of lifestyle advice based on results of VAR-models in a group of individuals with anhedonia, with an effect on momentary positive affect but not on depressive symptoms.

To the best of our knowledge, the current study is the first to investigate the association between social activation and suspiciousness during the UHR phase for psychosis using replicated single-subject time-series analyses. The intensive longitudinal design allowed us to examine the associations at the individual level and to make inferences about the directionality and temporal dynamics of the examined association. Although the design of repeated assessments over a period of 90 days is time-consuming and demanding for the participant, compliance was high and participants were highly motivated to take part in the study. Recent research also confirms that repeated assessments in daily life are feasible and acceptable in different psychiatric populations (Bos et al., 2019; Heijmans et al., 2019). Using this type of data, current and future research may also examine symptom dynamics and networks within and across subgroups of the clinical staging model of psychosis (see also other publications using mirorr data; van der Tuin et al., 2021, 2022), as well as potential explanatory characteristics for individual differences in the temporal associations, such as comorbid disorders.

Our study also has some limitations. First, due to the design of one-measurement-a-day it is possible that we missed variations if these occurred over different time intervals. Any associations over <1-day intervals likely ended up in the contemporaneous associations, for which we could not assess the direction. Second, the design and

statistical techniques used are not sufficient to establish whether the found associations also represent causal effects. Unmeasured common factors could still explain these associations. Third, we did not examine the type of social contact on a given day. It is likely that suspiciousness expresses itself differently in terms of social activation, depending on the individual one is with (e.g. colleague or family member). Future research could distinguish in types of contact by focusing on social contact with family or friends, or with strangers specifically. Fourth, the mini-SCAN was assessed for research purposes and diagnoses that were assigned with this instrument may not always be identical to the diagnoses assigned in the clinical health care centres. Although the risk of false positives is relatively low with the mini-SCAN (Nienhuis et al., 2010), it may have contributed to the high percentage of comorbid depressive disorders in the current sample. However, comorbidity of mental illness is the norm rather than the exception in the UHR population, especially given that participants are screened for UHR status at mental health centres where they are receiving treatment for a non-psychotic disorder. The literature indeed demonstrates that the majority of those at UHR for psychosis are in fact diagnosed with comorbid axis 1 disorders, in particular depressive disorders (Fusar-Poli et al., 2014; Rutigliano et al., 2016; Wilson et al., 2020). Therefore, we do not believe this has affected the generalizability of our sample. However, future research is recommended to examine whether similar (and variations of) patterns of results are found in samples with a primary diagnosis of a depressive disorder without psychotic symptoms. Last, participants were not selected on the basis of elevated levels of paranoia, and therefore one should not consider participants in this sample as paranoid by default.

#### 4.1. Conclusions

Using an idiographic analytic method we found that the association between social activation and suspiciousness is heterogeneous and person-specific in a sample of twenty individuals at UHR for psychosis. Findings suggest that social activation can have both a protective or aggravating effect of suspiciousness on a daily basis, depending on the specific individual. If true, this may have important implications for clinical practice. We recommend future studies to examine whether using results of single-subject studies in clinical practice to personalize treatment goals (e.g. focusing on coping versus social network) in fact leads to better treatment outcomes. In any case, our findings stress the importance of the social network as a resource for managing psychopathology and the potential it has in helping individuals at UHR of psychosis, be it in a way that is specific to each individual.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.schres.2023.10.012>.

#### CRedit authorship contribution statement

LAS contributed to the conception of the study, the analysis, interpretation of data and wrote the first manuscript of this study. TH contributed to the data analysis. MHN and AA contributed to the conception of the study. AABV, MV, GHMP, DvdB and ECP contributed to the conception of the study and interpretation of the data. CJA contributed to the data analysis and interpretation of data. JTWW and SHB contributed to the conception of the study, the analysis, and interpretation of data. All authors contributed to this manuscript through drafting or revising it critically for important intellectual content and approved this final version.

#### Funding

This work was supported by the Netherlands Organization for Scientific Research (NWO) (Veni JTWW: no. 016.156.019). The sponsor had no role in the study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to



submit the article for publication.

## Declaration of competing interest

None.

## Acknowledgements

We are thankful for the participants who took part in this study, as well as the interns who assisted in the data collection, especially Merel Muller. We would also like to thank the RoQua team ([www.roqua.nl](http://www.roqua.nl)) for building and maintaining the smartphone diary questionnaires.

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