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Associations between digital media use and psychotic experiences in young adults of Quebec, Canada: a longitudinal study

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Conflicts of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

ABSTRACT (249/250 words)

Purpose: Digital media use has been associated with psychotic experiences in youth from the community, but the direction of association remains unclear. We aimed to examine between- and within-person associations of digital media use and psychotic experiences in youth.

Methods: The sample included 425 participants aged 18-25 years (82.5% female) from the community, followed between May 2021 and January 2022 over 3 time points – of which 263 participants (61.9%) completed at least 2. Digital media use was self-reported as time spent daily on TV and streaming platforms, social media, and video games over the past 3 months. Psychotic experiences in the past 3 months were measured with the 15-item Community Assessment of Psychic Experiences. Associations between digital media use and psychotic experiences were estimated using a random-intercept cross-lagged panel model.

Results: On average, individuals who reported greater digital media use also reported higher levels of psychotic experiences (r=0.34, 95% CI: 0.15, 0.53). However, a person's variation in digital media use, relative to their personal average, was not significantly associated with subsequent variations in their levels of psychotic experiences, or vice-versa. Results were similar across TV/streaming, social media and video game use, and after adjusting for age, sex, education, sleep, physical activity, and cannabis use.

Conclusion: Individuals with a tendency for higher levels of digital media use also had a tendency for higher levels of psychotic experiences. Understanding this association

may help personalize mental health interventions for people with psychotic experiences, which may be offered digitally to promote their accessibility.

KEYWORDS: psychotic-like experiences, psychotic symptoms, screen time, technology use, internet use, chronotype

INTRODUCTION

Psychotic experiences are disturbances of thought and perception that exist along a continuum within the community [1] and are more common in youth [2]. These experiences include paranoid beliefs, hearing voices when alone, and a range of unusual perceptions. Psychotic experiences in adolescents and young adults are associated with higher risk of subsequent psychotic disorders, as well as a range of other mental health problems including depression, anxiety, and suicide attempts [1, 3–5]. Thus, early identification of psychotic experiences can guide prognostic and treatment targets to improve mental health [6, 7].

In recent years, the use of digital media has gained attention as a potential environmental risk factor for psychotic experiences in youth [8–10]. Digital media, such as TV and streaming platforms, social media, and video games, have grown in popularity over the past decades, and more rapidly during the COVID-19 pandemic [11, 12]. In the province of Quebec, Canada, an estimated 97% of the population aged 18-24 years owns a smartphone, and 45% has reported that their screen time “substantially increased” between 2020 and 2021 [12]. Digital media use can reduce key protective factors of mental health, for example by taking time away from sleeping or exercising [13], or by becoming the source of addiction-like behaviors [14]. Through these or other mechanisms, digital media use has been hypothesized to be associated with psychotic experiences [10, 15]. Studies examining digital media use and mental health in the general population have found inconsistent associations, notably as a function of study design and outcomes of interest [16, 17]. In addition, most studies have focused on

general well-being or depression as outcomes [14, 18], while little is known about the association with psychotic experiences.

Associations between digital media use and psychotic experiences

In adolescents and young adults from the community, there is evidence that higher levels of psychotic experiences are associated with higher levels of internet addiction or maladaptive internet use; however, most studies have been cross-sectional [8–10]. Thus, whether digital media use preceded psychotic experiences, or vice-versa, could not be determined. In fact, existing evidence points to a bidirectional association. On the one hand, changes in digital media use may precede changes in psychotic experiences, for example if digital media use induces thought and perceptual disturbances [19, 20]. In an experience sampling study (44 participants with and without psychosis), aspects of social media use, such as venting about feelings and perceived low social rank, were associated with subsequent increases in paranoia, possibly due to undesirable responses from others and negative social self-comparisons [21]. On the other hand, changes in psychotic experiences may precede changes in digital media use, for example if psychotic experiences lead to preference for digital media over other activities [22]. A systematic review found that people with psychosis spend more time on chat rooms and video games than people without psychosis, possibly as a means of fostering relationships [22].

To understand the temporal relationship between digital media use and psychotic experiences, between-person and within-person associations should be untangled. *Between-person associations* indicate whether individuals' propensity for higher digital

media use is associated with their propensity for more psychotic experiences. *Within-person associations* indicate whether a person's increase or decrease in digital media use over time is associated with subsequent changes in their psychotic experiences, or vice-versa. Within-person associations offer stronger evidence for putative causal effects because participants are analyzed as their own comparators, thus indirectly controlling for many measured and unmeasured stable individual characteristics [23].

Other factors likely influence the association between digital media use and psychotic experiences. Male and female individuals have different profiles of digital media use [12], and some evidence points to stronger associations with mental health among female individuals [16]. While previous research has often aggregated different types of digital media use, such as TV and streaming platforms, social media, or video games, these platforms engage users in different ways and may also be differently associated with psychotic experiences [13, 24]. Sociodemographic characteristics and lifestyle-related behaviors may potentially confound the association between digital media use and mental health [23, 25, 26]. For example, although digital media use may affect sleep, a person may spend more time on digital media at night because of their tendency to sleep late [27], a tendency which in turn is a potential risk factor for mental ill-health [28]. Exploring how potential confounders such as sociodemographic characteristics and lifestyle-related behaviors impact the association of digital media use with psychotic experiences may help uncover pathways of risk that precede both outcomes.

Study aims

Using a longitudinal sample of youth, we aimed to examine the association between digital media use and psychotic experiences. We investigated both between- and within-person associations. We hypothesized that, after adjusting for the between-person association, there would be bidirectional associations between digital media use and psychotic experiences at the within-person level. We also explored sex differences, associations of specific types of digital media use (TV or streaming, social media, and video games), and the influence of potential confounding variables (sociodemographic characteristics and lifestyle-related behaviors) on the between-person association.

METHODS

Participants

Participants were from the Green/Screen Study (https://osf.io/y2b9z/), a convenience sample of young adults (18-25 years) residing in the Canadian province of Quebec and speaking one of the two official languages, French or English. Participants were assessed over three time points during the following periods: May 27 to June 14, 2021 (T1), September 8 to October 13, 2021 (T2), and December 2 to January 11, 2022 (T3). Questionnaires were administered online through a custom survey platform (https://www.elaborer.org). The study received ethical approval from the institutional review board of the University of Quebec at Montreal (#4552_e_2021).

Participants were recruited through sponsored advertisement which targeted the aforementioned age range and geographical region. Advertisement was placed on four popular social media platforms (Facebook, Instagram, Twitter and Reddit) and two classified advertisement websites (Kijiji and Craigslist). Individuals were directed to the

study website where the project and consent form were presented. All participants provided their consent via electronic signature. To encourage participation and minimize attrition, we offered a draw of 20 lots of $25 CAD after the first study time point and 10 lots of $100 CAD after the third time point.

Measures

Psychotic experiences were measured at each time point with the 15-item Community Assessment of Psychic Experiences [29, 30]. This version of the questionnaire captures 15 psychotic or psychotic-like experiences in the past 3 months, including persecutory ideations (e.g., “Have you ever felt as if people seem to drop hints about you or say things with a double meaning?”), bizarre experiences (e.g., “Have you ever felt as if the thoughts in your head are not your own?”), and perceptual abnormalities (e.g., “Have you ever heard voices when you are alone?”). The frequency of each experience is rated on 4-point scale from “never” to “nearly always”, and the global score is the averaged frequency of all items (range: 1–4). A screening cut-off of 1.75 has been proposed for psychotic disorders [31]. The questionnaire has good validity and reliability [29, 32, 33]. In accordance with the World Mental Health Composite International Diagnostic Interview [34], we instructed participants not to include experiences that occurred only while under the influence of alcohol, drugs, or medications that were not prescribed.

Digital media use was measured at each time point with three items adapted from the Coronavirus Health and Impact Survey [35]. Items captured daily use in the past 3 months of (1) TV and streaming services, (2) social media, and (3) video games. For

each item, the amount of use was rated as 1=”never/did not use”, 2=”under 1 hour”, 3=”1–3 hours”, 4=”4–6 hours”, and 5=”more than 6 hours”. Overall digital media use was indexed by summing the three items (range: 3–15).

Potential confounding variables were measured at the first time point. These included age, sex (male or female), educational attainment, sleep phase delay, physical activity, and cannabis use. Educational attainment was dichotomized as 0=”high school diploma or lower” and 1=”some college or higher”. Lower educational attainment has been associated with greater digital media use [36] and higher risk of psychotic experiences in the general population [25]. For descriptive purposes, we also report employment and student status (none, part time or full time) at baseline. Sleep phase delay was measured by assessing typical sleep habits using the Munich Chronotype Questionnaire [27]. Sleep phase delay, also known as evening chronotype, indicates a tendency to initiate sleep later in the night, and to wake up later in the morning. Greater sleep phase delay has been associated with more psychotic experiences [37] and greater computer use [38] in community-based samples. As recommended by the questionnaire creators [39], we calculated sleep phase delay as the midsleep point (i.e., time of the day corresponding to the middle of the sleep period; range: 0–24 hours) on days without engagements (i.e., without work or school), corrected for sleep debt accumulated during days with engagements. Physical activity was estimated in Metabolic Equivalent Task (MET)–minutes/week using the International Physical Activity Questionnaire – Short Form [40]. Frequency of cannabis use in the past 2 weeks was reported on a 4-point scale from “never” to “everyday” [41]. As aspects of lifestyle that predispose to screen-based sedentary activities, both lower levels of physical activity

and higher levels of cannabis use could be associated with greater digital media use and higher levels of psychotic experiences [26].

Statistical analysis

Analyses were conducted in R version 4.1.2 (R Foundation for Statistical Computing). Codes are available at https://osf.io/y2b9z/. Following recommendations regarding analysis of internet surveys [42, 43], data of potentially lower quality from rushed or careless completion of the questionnaire were identified, using criteria based on short completion times, inconsistent responses, and implausible response patterns (see Supplementary Note 1).

Descriptive analyses were performed to report characteristics of the sample according to attrition status. To estimate proportions of variance explained by between-person differences versus within-person fluctuations over the three time points, we calculated the intraclass correlation coefficients (ICCs) of digital media use and psychotic experiences. The ICC of a measure corresponds to the proportion of between-person variance, while the proportion of within-person variance is 1-ICC (i.e., the remaining variance).

Associations between digital media use and psychotic experiences

To examine associations between digital media use and psychotic experiences, we used random-intercept cross-lagged panel models [44, 45]. This type of model allowed us to consider two types of associations: (1) stable differences between persons (i.e., between-person associations, captured by the correlation of random intercepts); and (2)

associations between digital media use and psychotic experiences related to fluctuations over time (i.e., within-person associations, captured by cross-lagged regressions).

Here, random intercepts indicate individuals' stable propensities for digital media use and psychotic experiences; the correlation between these two intercepts indicates whether individuals with more psychotic experiences also differ in their levels of digital media use compared with other individuals. Cross-lagged regressions identify whether individuals who increase their digital media use will subsequently experience a change in psychotic symptoms, and vice-versa.

We estimated the model with the *lavaan* package [46], using robust standard errors to accommodate multivariate non-normality. Missing data was handled with the Full Information Maximum Likelihood: this method allows the inclusion of participants with missing data and is robust to missingness at random [47]. At the within-person level, we assumed that the strength of associations between digital media use and psychotic experiences would be of similar magnitude over time. We thus constrained the corresponding autoregressive and cross-lagged regression coefficients to equality. To account for different means of digital media use and psychotic experiences over the 3 time points, we allowed the intercepts to vary over time, which improved model fit [45]. We defined statistical significance as two-tailed $P<.05$, and the smallest effect size of interest as correlation coefficient (r) or standardized regression coefficient (β) of .10 [48, 49]. We defined Comparative Fit Index (CFI)>0.90 as acceptable and >0.95 as good fit; and both Root Mean Square Error Approximation (RMSEA) and Standardized Root Mean Squared Residual (SRMR) <0.08 as acceptable and <0.05 as good fit [50, 51].

We then tested three variations of the random-intercept cross-lagged model. First, to explore how attrition may have affected the results, we restricted the sample to participants who had completed at least two time points. Second, to test for sex differences, we examined male and female as separate groups in the model. Third, to explore associations of specific types of digital media use, we separately examined TV and streaming, social media, and video games.

Lastly, we explored the influence of potential confounding variables on the between-person association of overall digital media use and psychotic experiences. To do so, we separately regressed their random intercepts on age and sex, educational attainment, sleep phase delay, physical activity, and cannabis use (i.e., we generated 5 models). We considered (1) whether the potential cofounding variables were significantly associated with the random intercepts of digital media use and psychotic experiences, and (2) the extent to which adjusting for these covariates accounted for the statistical association between the two random intercepts.

RESULTS

Of 445 individuals who completed the assessments at the first time point, 20 were excluded due to being outside the eligible age range. Then, of the 425 eligible participants, 18 (4.24%) were identified as having data of potentially lower quality because they completed the first assessment in <6 minutes or provided straight-line patterns of responses. Due to being <5% of the sample size, they were not removed from analyses [42] (see Supplementary Note 1).

<Table 1>

Table 1 presents the descriptive statistics of the total sample (N=425) sociodemographic and key study variables at the first time point. Of this sample, 263 (61.9%) completed at least 2 of the 3 time points and 177 completed all 3 time points (41.6%). Compared with participants who completed 2 or 3 time points, participants who completed only the first assessment were more likely to report lower educational attainment and endorsed higher levels of psychotic experiences (Table 1).

Mean (standard deviation) scores for psychotic experiences were 1.32 (0.35) at the first time point, 1.23 (0.27) at the second time point, and 1.21 (0.29) at the third time point. At baseline, 345 (81.3%) participants endorsed at least one of the psychotic experience items, and 44 (10.4%) participants met the screening cut-off for psychotic disorders. Mean (standard deviation) scores for overall digital media use were 8.88 (2.32) at the first time point, 8.30 (2.12) at the second time point, and 8.23 (2.19) at the third time point.

Proportions of between-person variance, i.e., ICCs, were 0.77 (95% CI: 0.72, 0.80) for psychotic experiences, 0.55 (95% CI: 0.47, 0.61) for overall digital media use, 0.48 (95% CI: 0.40, 0.55) for TV or streaming use, 0.47 (95% CI: 0.39, 0.54) for social media use, and 0.70 (95% CI: 0.65, 0.75) for video game use.

Associations between digital media use and psychotic experiences

The random-intercept cross-lagged model produced acceptable fit: $\chi^2(6)=16.32$, $p=.01$; CFI=0.983; RMSEA=0.064 (90% CI: 0.027, 0.102); SRMR=0.052. Figure 1 presents standardized estimates (see Supplementary Figure 1 for unstandardized estimates). At the between-person level, the random intercepts for overall digital media use and

psychotic experiences were significantly correlated at a magnitude above the smallest effect size of interest. This finding indicates that the propensity of individuals for higher levels of psychotic experiences was associated with their propensity for higher levels of overall digital media use.

Cross-lagged associations between overall digital media use and psychotic experiences were not statistically significant. In other words, individuals using digital media more than their personal average at one time point did not have significantly more psychotic experiences at the next time point. Similarly, individuals reporting more psychotic experiences than their average at one time point did not report significantly higher digital media use at the next time point. However, although these cross-lagged associations were not statistically significant, their confidence intervals overlapped with the smallest effect sizes of interest in both directions (-0.10 and +0.10), indicating that meaningful associations could not be reliably ruled out.

<Figure 1>

After restricting to participants with complete data on at least 2 time points (n=263), the model produced similar estimates and fit indices (Supplementary Figure 2). Due to the small proportion of male participants, we did not examine group-based estimates of sex differences but rather restricted the analysis to female participants. We obtained estimates similar to those of the initial model (Supplementary Figure 3). With the complete sample of N=425, separating digital media use into TV and streaming, social media, and video games yielded similar estimates with acceptable to good fit indices (see Supplementary Figures 4, 5 and 6). All three types of digital media use were

significantly correlated with psychotic experiences at the between-person level; TV and streaming: *r*=0.25 (95% CI: 0.07, 0.42); social media use: *r*=0.28 (95% CI: 0.08, 0.48); and video game use: *r*=0.23 (95% CI: 0.07, 0.38). Again, this indicates that the propensity of individuals for higher levels of psychotic experiences was associated with their propensities for higher levels of each type of digital media use. Cross-lagged associations were not statistically significant, but their confidence intervals generally overlapped with the smallest effect sizes of interest (-0.10 and +0.10). Thus, after adjusting for between-person differences, these estimates do not reliably rule in or out whether a person's increase in either type of digital media is associated with a subsequent change in their levels of psychotic experiences. The same is true for the other direction of association, starting with an increase or decrease in the levels of psychotic experiences to a subsequent change in either type of digital media use.

Table 2 presents the regression estimates of overall digital media use and psychotic experiences (random intercepts) on potential confounding variables. Several associations were both statistically significant and above the smallest effect size of interest. According to these criteria, older age was associated with lower levels of psychotic experiences but was not associated with levels of digital media use. Male sex was associated with higher digital media use but not psychotic experiences. Higher educational attainment was associated with lower levels of both overall digital media use and psychotic experiences. Greater sleep phase delay was associated with higher levels of both digital media use and psychotic experiences. Physical activity was not associated with either outcome. Cannabis use was associated with higher levels of psychotic experiences but not digital media use.

<Table 2>

Figure 2 presents the correlation between random intercepts for overall digital media use and psychotic experiences after adjusting for those variables. The correlation coefficient remained significant and of similar magnitude across adjustments.

<Figure 2>

DISCUSSION

Among young adults recruited from the community, those with higher levels of psychotic experiences also tended to report higher use of digital media, an association that was observed across different types of digital media and independently of sociodemographic and lifestyle characteristics. At the individual level, changes in digital media use over time were not significantly associated with subsequent changes in psychotic experiences, but small-effect associations could not be reliably ruled out.

The between-person association of digital media use and psychotic experiences is consistent with previous work [8–10]. For example, in a population-based sample of 973 Irish adolescents, scores on the Young's Diagnostic Questionnaire (which captures patterns of internet use resulting in psychological or social distress) were cross-sectionally associated with the odds of having psychotic experiences [9]. In a sample of adults from the UK Biobank, playing vs. not playing computer games was associated with greater odds of psychotic experiences [52]. The first study used self-reports of "pathological" internet use, the second study employed a dichotomous assessment of usage, and the present study investigated self-reports of time spent using digital media.

These constructs are different, and emerging evidence shows that measures of "pathological use" correlate more strongly with measures of mental health, while measures of "time spent using" correlate more strongly with objective measures of digital media use such as those recorded by a phone activity tracker (albeit imperfectly, as discussed in the limitations below) [14, 53, 54]. On its own, time spent on digital media use does not provide information on functional impairment or distress arising from technology usage. However, this self-reported behavior is commonly assessed in clinical practice, alongside other lifestyle factors such as sleep and physical activity [55]. In this context, we suggest that the identification of a propensity for higher levels of digital media use could provide information on the putative risk for psychotic experiences. Stable individual characteristics likely explain, to some extent, the shared propensity for digital media use and psychotic experiences.

Lower educational attainment and greater sleep phase delay were significantly associated with individual propensities for digital media use and psychotic experiences. Previous work partially supports these associations. In a sample of US undergraduate students, higher levels of digital media use were associated with subsequently lower grades after adjusting for background educational and demographic characteristics [36]. However, in a systematic review, socio-economic status was not consistently associated with psychotic experiences [2]. In a survey of 1789 adults from the general population in UK, sleep phase delay was associated with delusional mood (but no other types of psychotic experiences) [37], while in 439,933 adults from the UK Biobank, it was associated with higher levels of computer use [38]. Of note, these studies and the present work cannot differentiate academic performance or sleep as confounders (i.e.,

preceding digital media use and psychosis expression) versus mediators (i.e., explaining a putative effect of digital media use on psychotic experiences) – longer periods of follow-up would be required to untangle the sequence of exposures. Yet we found that neither sleep phase delay, educational attainment, nor the other potential confounding variables substantially explained the overall association of digital media use and psychotic experiences. This leaves open the question of why individuals with higher psychosis expression tend to use digital media more. Rather than a reflection of technology causing or exacerbating psychosis expression, the explanation may lie in technological preference among individuals with psychotic experiences [15]. This multifactorial preference could be motivated for example by the fulfillment of psychological needs, such as leisure, social connections or self-efficacy, in context of psychosis [56–58].

At the within-person level, changes in digital media use were not significantly associated with changes in psychotic experiences. Limited research has examined these longitudinal associations. In a sample of 44 individuals with and without psychosis followed over 6 days, there was no association between momentary reports of social media use and subsequent increases in paranoia; however, specific behaviors such as posting about feelings, venting on social media, or perceive low social rank during usage were significant predictors [21]. Studies on other mental health outcomes have generally found minimal or no within-person associations with digital media use in the general population [59–61]. For example, in 10,000 adults from the general Dutch population followed over 6 years, year-to-year changes in social media use were not prospectively associated with changes in well-being after adjusting for the between-

person association [60]. In the present study, cross-lagged associations were not statistically significant, but confidence intervals were relatively wide and overlapped with the smallest effect size of interest of $|\beta|=.10$. Lack of significant associations may reflect insufficient variance at the within-person level, for example if measures were not sensitive enough to changes over time, or if these changes occurred over different time frames than the ~3-month intervals examined here. Other factors that were not measured in the present study may moderate the within-person associations of digital media use with psychotic experiences: examples include aspects of technology use (e.g., passive or active, alone or with others) [62], need satisfaction (e.g., of relatedness) [63], distress, or functional impairments arising from digital media use [14]. It should be noted that the three study time points coincided with different periods of restrictions related to the COVID-19 pandemic in Quebec, Canada – from gradual deconfinement during the first study time point [64], to abrupt re-confinement during the third [65]. Evolving restrictions likely yielded changes in stress and psychosocial functioning throughout, with different impacts on mental health as a function of individual risk factors (e.g., living alone) [66]. At the within-person level, then, these factors may have been a source of unmeasured variability, potentially limiting the study's statistical power to detect general associations between digital media use and psychotic experiences.

Strengths and limitations

Repeated measures of digital media use and psychotic experiences allowed us to examine, for the first time, their between- and within-person associations. We considered overall as well as specific types of digital media use and found consistent

correlations with psychotic experiences at the between-person level. Building on previous work, we were able to consider multiple potential confounders of between-person associations, such as educational attainment and sleep phase delay, and showed they did not explain participants' shared propensities for digital media use and psychotic experiences.

Our study had limitations. Self-reports of digital media use only partially reflect objective use, and shared method variance with self-reported psychotic experiences may inflate their associations [53, 67]. However, from a translational standpoint, self-reports of digital media use are more accessible to the clinician's questioning than objective measurement (such as smartphone monitoring), which is more invasive and may fail to capture digital media use across multiple devices (computer, phone, TV, etc.). Although subjective and objective measures of digital media use are only moderately correlated, these indices seem to have convergent predictive validity for mental health outcomes [68]. Our study also suffered from attrition. Although the analytical method we used is robust to missingness at random, bias is possible if attrition occurred as a function of the strength of association between psychotic experiences and digital media use. Another limitation is that due to convenience sampling, our cohort was not representative of the general population, notably with an overrepresentation of female individuals and higher socioeconomic status. It is possible that individual characteristics such as male gender (which is associated with video game addiction [69]) or other features could lead to stronger associations between digital media use and psychotic experiences [70], for example as a result of greater psychosis propensity and/or more maladaptive forms of digital media use. Lastly, online data collection is prone to rushed

or careless completion of questionnaires [42]. After searching for low-quality data using systematic criteria, we identified less than 5% of problematic entries which are thus expected to have minimal impact on the analyses [42]. However, due to the difficulty of reliably identifying data of low quality, there may be unexplained variability in the findings stemming from additional problematic entries that were not identified.

Future directions include replication in other populations, including those at risk of psychosis or with psychotic disorders [71], with potentially distinct profiles of digital media use. Examining digital media use over different time scales, from day-to-day variations to long-term trajectories over several years, may provide additional information on its association with psychotic experiences. Future research should also aim to identify what underlies individuals' shared propensity for psychosis expression and digital media use. If compensatory strategies are at play (e.g., using technology to foster relationships), then clinicians should be mindful of those when counselling youth about optimal "screen time". Insights into mechanisms of shared propensity may also help develop better digital interventions for individuals with psychotic experiences, such as mental health apps, virtual reality therapy, or online peer support [72]. Considering youth with psychotic experiences have an elevated risk of subsequent psychopathology [4, 5], interventions that tap into their technological preferences may provide accessible and scalable means of improving their mental health outcomes.

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Table 1. Descriptive statistics on sociodemographic and key study variables at baseline in the total sample and according to attrition status

	All included participants (N=425)	**Comparison of characteristics according to attrition status**		
		Participants who completed ≥2 time points (N=263)	**Participants who completed the first time point only (N=162)**	***p***
Age in years, Median [25th;75th]	22.0 [20.0;24.0]	22.0 [19.5;24.0]	22.0 [20.0;24.0]	.66
Sex, N (%):				.10
Female	348 (82.5%)	222 (85.1%)	126 (78.3%)	
Male	74 (17.5%)	39 (14.9%)	35 (21.7%)	
Educational attainment, N (%):				.04
High school or lower	112 (26.5%)	60 (22.9%)	52 (32.3%)	
Some college or higher	311 (73.5%)	202 (77.1%)	109 (67.7%)	
Employment, N (%):				.99
None	127 (30.1%)	48 (29.6%)	79 (30.4%)	
Part time	199 (47.2%)	77 (47.5%)	122 (46.9%)	
Full time	96 (22.7%)	37 (22.8%)	59 (22.7%)	

	All included participants (N=425)	Comparison of characteristics according to attrition status		
		Participants who completed ≥2 time points (N=263)	Participants who completed the first time point only (N=162)	*p*
Studying, N (%):				.26
None	91 (21.7%)	41 (25.5%)	50 (19.3%)	
Part time	47 (11.2%)	15 (9.32%)	32 (12.4%)	
Full time	282 (67.1%)	105 (65.2%)	177 (68.3%)	
Psychotic experiences, Mean (SD)	1.32 (0.35)	1.29 (0.34)	1.38 (0.36)	.008
Overall digital media use, Mean (SD)	8.88 (2.32)	8.79 (2.31)	9.03 (2.33)	.22

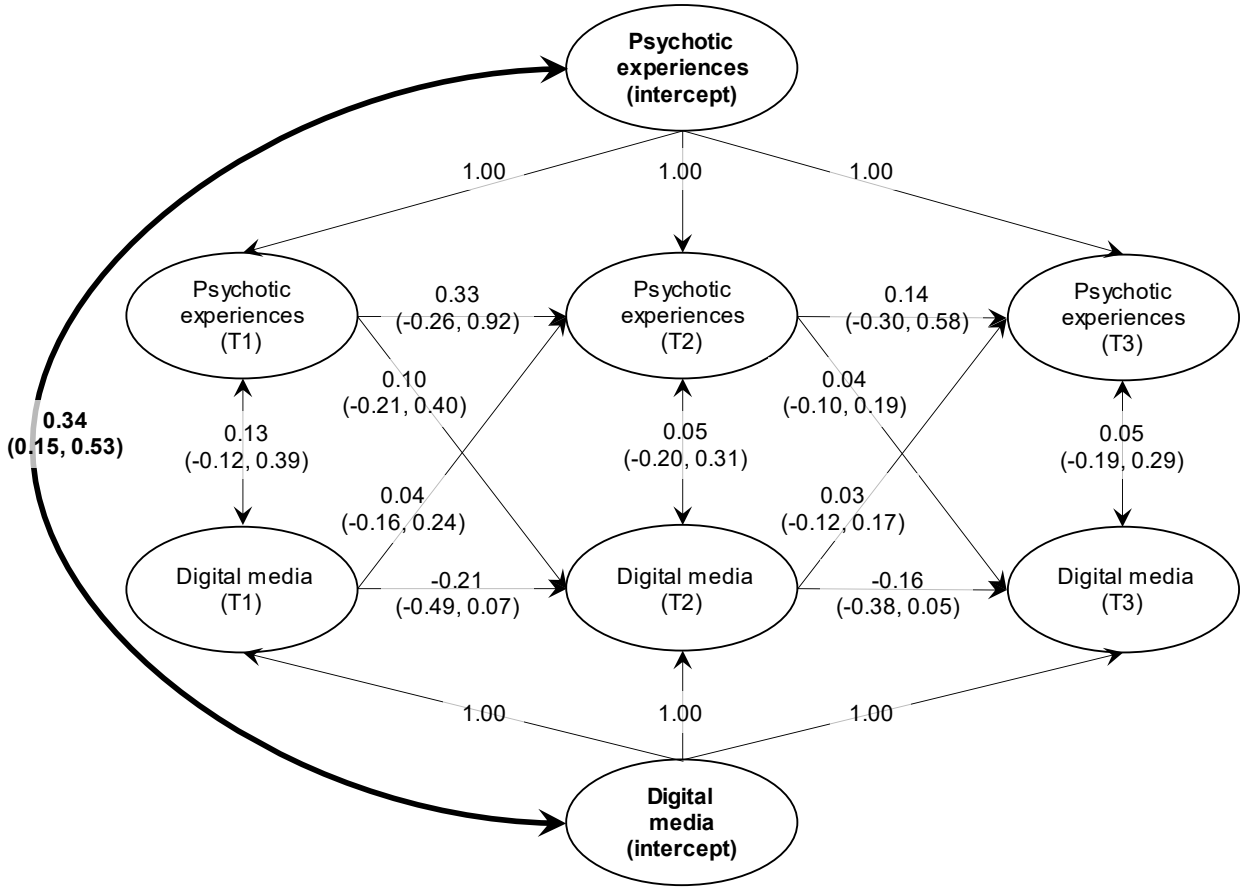
Participants who completed 2+ time points were compared with completers of only 1 time point using Kruskal-Wallis and chi-squared tests. Psychotic experiences were measured with the 15-item Community Assessment of Psychic Experiences (range: 1–4) [29]. Overall digital media use included TV and streaming platforms, social media, and video games based on the Coronavirus Health and Impact Survey (range: 3–15) [35]. SD: standard deviation.

Table 2. Associations of potential confounders with participants' propensities for overall digital media use and psychotic experiences

Potential confounders	**Standardized estimates (95% confidence intervals)**	
	Association with random intercept of overall digital media use	**Association with random intercept of psychotic experiences**
Age in years	-0.07 (-0.17, 0.04)	**-0.26 (-0.36, -0.16)**
Male sex	**0.24 (0.12, 0.36)**	0.11 (-0.03, 0.25)
Higher educational attainment	**-0.21 (-0.33, -0.10)**	**-0.38 (-0.49, -0.28)**
Sleep phase delay	**0.33 (0.22, 0.45)**	**0.28 (0.14, 0.41)**
Physical activity	0.00 (-0.12, 0.13)	0.01 (-0.12, 0.14)
Cannabis use	0.06 (-0.05, 0.17)	**0.22 (0.09, 0.35)**

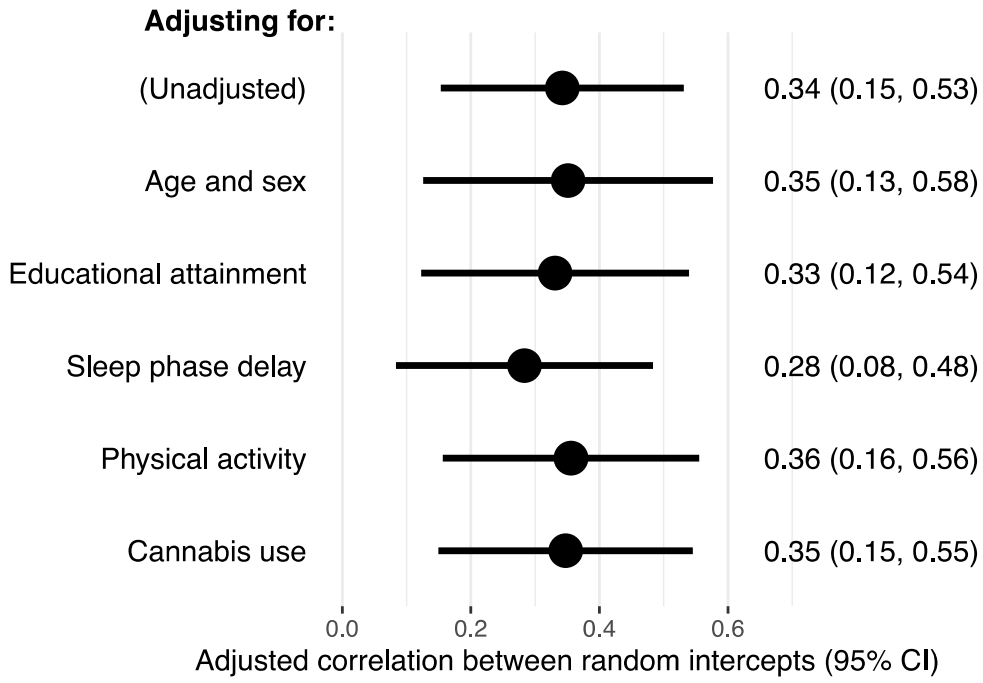
Random-intercept cross-lagged panel model (N=425 minus <5% removed due to missing data on potential confounders). Random intercepts for overall digital media use and psychotic experiences were regressed on potential confounders, each in separate models, except for age and sex which were included in the same model. Potential confounders were measured at baseline. Higher educational attainment (dichotomous) was defined as some college or higher (reference: high school or lower). Sleep phase delay was measured with the Munich Chronotype Questionnaire [27]; higher values indicate greater delay of the sleep phase, i.e., evening chronotype. Physical activity was measured in metabolic equivalent of task (MET) per week with the short-form International Physical Activity Questionnaire [40]; scores were divided by 1000 for rescaling. Cannabis use (dichotomous) was defined as 1-2 uses or more in the past 2 weeks (reference: no use in past 2 weeks). In bold: statistically significant associations.

Figure 1. Associations between overall digital media use and psychotic experiences within and between persons



Random-intercept cross-lagged panel model (N=425), standardized estimates (95% confidence intervals). Participants' propensities for psychotic experiences (up) and overall digital media use (bottom) are captured by time-varying random intercepts (in bold). The correlation between intercepts (also in bold) is thus at the between-person level. Associations among repeated measures at study time points T1, T2 and T3 are within persons. Paths from intercepts to repeated measures were constrained to 1.00 [73].

Figure 2. Unadjusted and adjusted association between overall digital media use and psychotic experiences at the between-person level



Random-intercept cross-lagged panel model (N=425 minus <5% removed due to missing data on potential confounders). Random intercepts for overall digital media use and psychotic experiences were regressed on potential confounders, each in separate models, except for age and sex which were included in the same model. Potential confounders were measured at baseline. Higher educational attainment (dichotomous) was defined as some college or higher (reference: high school or lower). Sleep phase delay was measured with the Munich Chronotype Questionnaire [27]; higher values indicate greater delay of the sleep phase, i.e., evening chronotype. Physical activity was measured in metabolic equivalent of task (MET) per week with the short-form International Physical Activity Questionnaire [40]; scores were divided by 1000 for rescaling. Cannabis use (dichotomous) was defined as 1-2 uses or more in the past 2 weeks (reference: no use in past 2 weeks).

Supplementary Material

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Supplementary Note 1. Data quality inspection

Internet surveys can suffer from responses of low quality arising from rushed or careless completion. To identify data of potentially lower quality, we began by inspecting individual data entries to detect unusual or implausible patterns of response. Then, in accordance with recommendations and work from others,[1,2] we selected three criteria to identify data of potentially lower quality: (1) total completion time of less than 6 minutes, (2) inconsistent self-report of mental disorder diagnoses, and (3) straight-line responses on two scales. These criteria and the number of participants fulfilling them are presented below. The criteria were applied on the total baseline sample of n=425 (i.e., after exclusion of 20 participants whose age was outside the eligible range). We defined data of potentially lower quality as meeting at least one of the criteria. In keeping with recommendations by Leiner,[1] we elected to remove these participants from analyses only if they exceeded 5% of the total sample size. Below 5%, the potential impact of low-quality data was deemed to be minimal and thus not outweighing the risk of inadvertently removing valid data.

Total completion time

The median completion time was 10.62 minutes (lower quartile: 8.72; upper quartile: 13.45). We estimated that a minimum of 6 minutes was necessary to adequately answer most of the baseline questionnaire, which included a total of 64 items. Thus, we defined the first criterion as total completion time of less than 6 minutes. Of the 425 participants, 10 (2.35%) completed the questionnaire in less than 6 minutes (range: 3.08–5.97 minutes).

Self-report of mental illness diagnoses

Participants were asked the following question: “Currently or in the past, have you had any mental illness diagnosed by a mental health professional?” Checkboxes were presented with the instruction to select all that apply: “None”, “Depression”, “Anxiety disorder”, “Psychotic disorder”, “Bipolar disorder”, “Alcohol or drug use problem”, “Other”. Selecting both “None” and at least one of the disorders was defined as a criterion for data of potentially lower quality. Of 425 participants, none met this criterion.

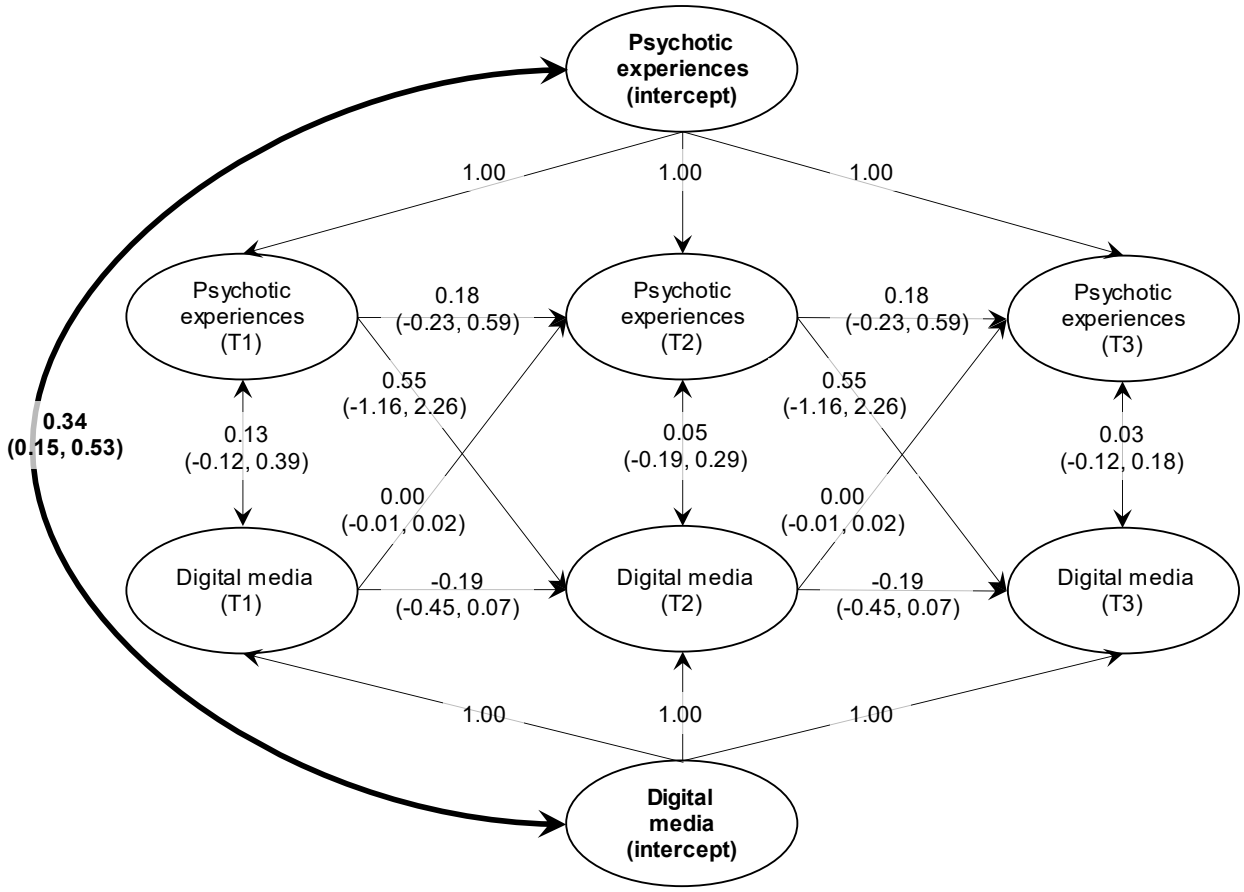
Straight-line responses

We searched for straight-line responses (i.e., where the same answer is selected for all items of a scale) in two scales: the Patient Health Questionnaire (PHQ-9)[3] and the Generalized Anxiety Disorder (GAD-7).[4] We defined the criterion as providing straight-line responses on both the PHQ-9 and the GAD-7. We selected these scales because they include multiple items, and they generate total scores that are relatively normally distributed. In contrast, we did not use the Community Assessment of Psychic Experiences (CAPE-P15)[5] for this criterion because its score distribution is typically skewed, with many participants selecting the lowest answer on all items. Of 425 participants, 9 (2.12%) met the criterion.

Number of criteria fulfilled by participants

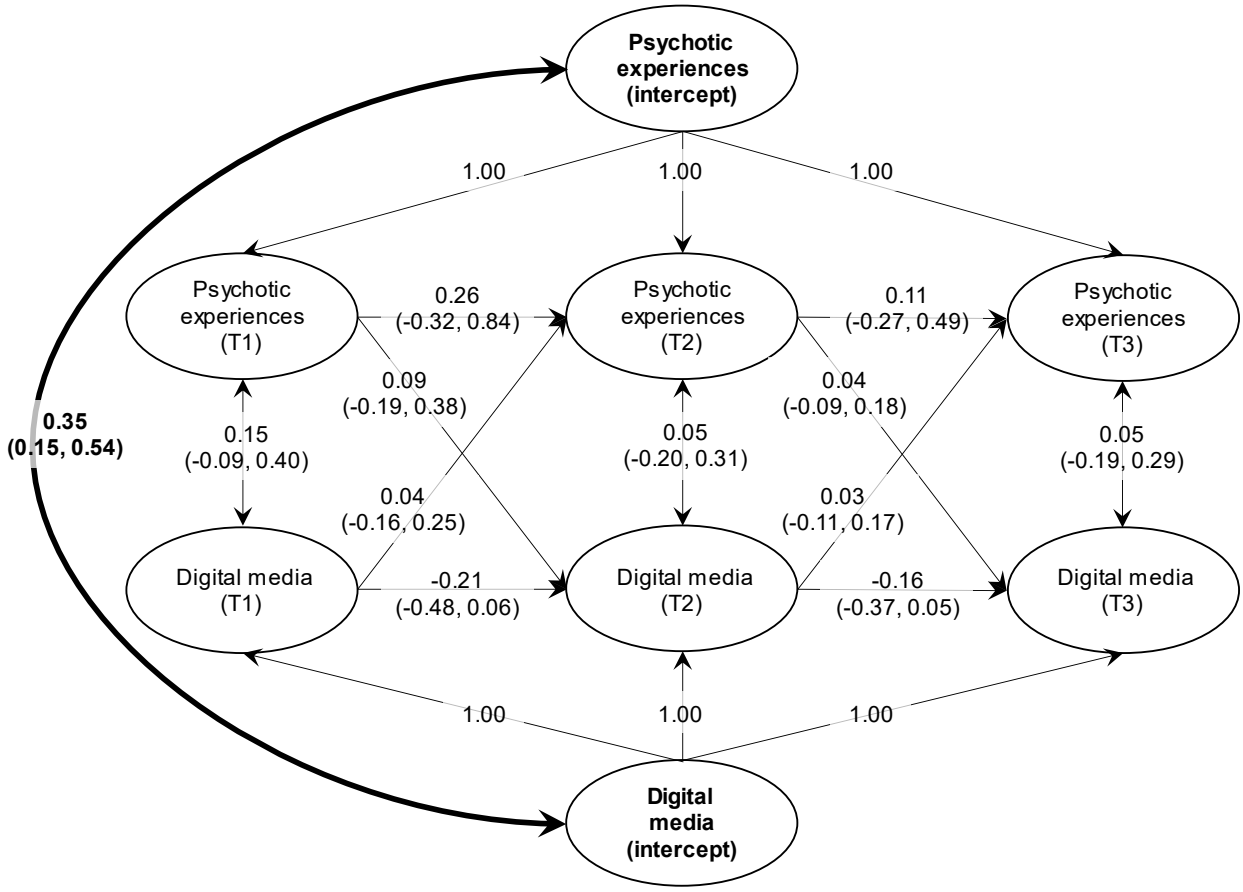
In total, 18 participants (4.24% of the sample) met at least 1 criterion. Of those, only 1 participant met 2 criteria; no participant met all three criteria. Because fewer than 5% of participants fulfilled at least one criterion, we did not remove them from analyses.

Supplementary Figure 1. Associations between overall digital media use and psychotic experiences within and between persons (unstandardized estimates)



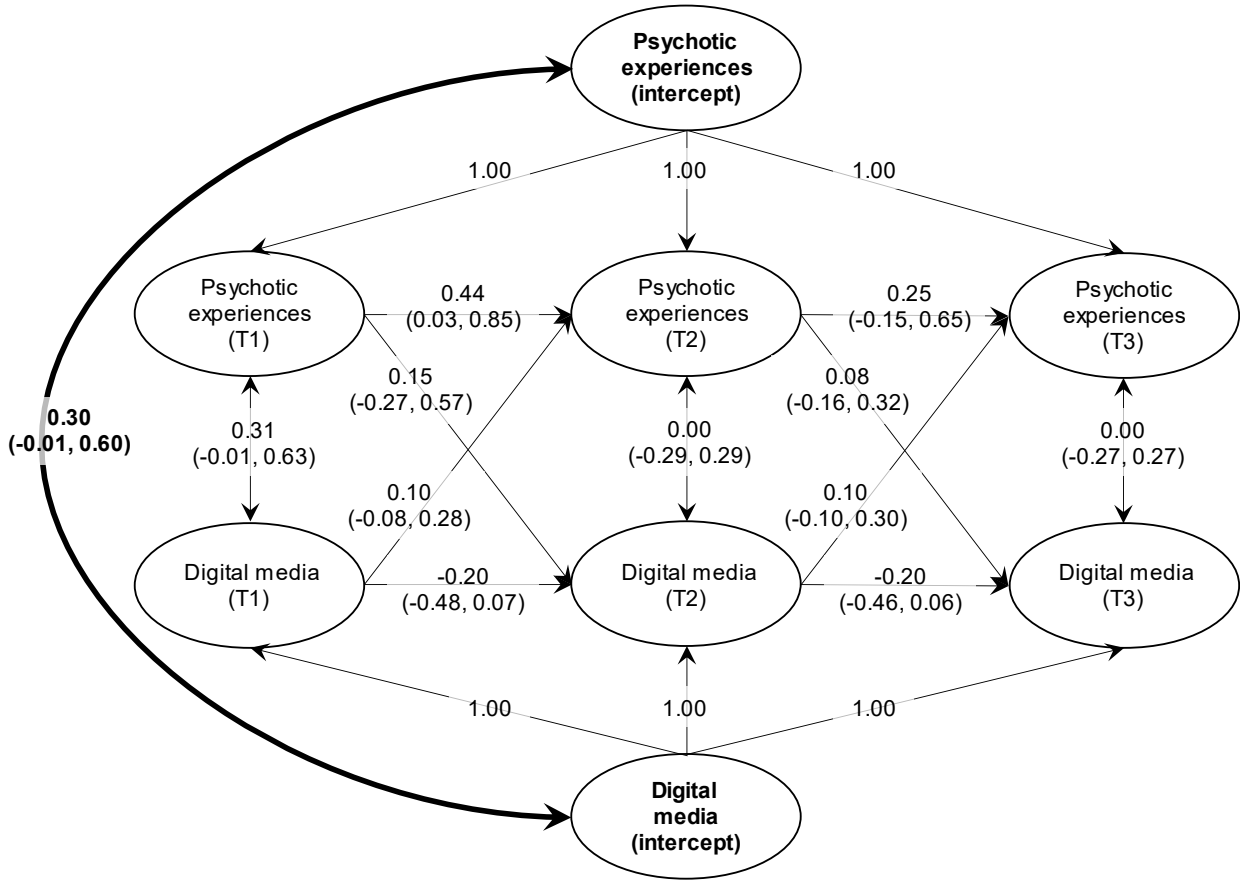
Random-intercept cross-lagged panel model (N=425), unstandardized estimates (95% confidence intervals). Participants' trait propensities for psychotic experiences (up) and overall digital media use (bottom) are captured by time-varying random intercepts (in bold). The correlation between intercepts (also in bold) is thus at the between-person level. Associations among repeated measures at study waves T1, T2 and T3 are within persons. Paths from intercepts to repeated measures were constrained to 1.00. The model produced acceptable fit: $\chi^2(6)=16.32$, $p=.01$; CFI=0.983; RMSEA=0.064 (90% CI: 0.027, 0.102); SRMR=0.052.

Supplementary Figure 2. Sensitivity to attrition of associations between overall digital media use and psychotic experiences within and between persons (standardized estimates)



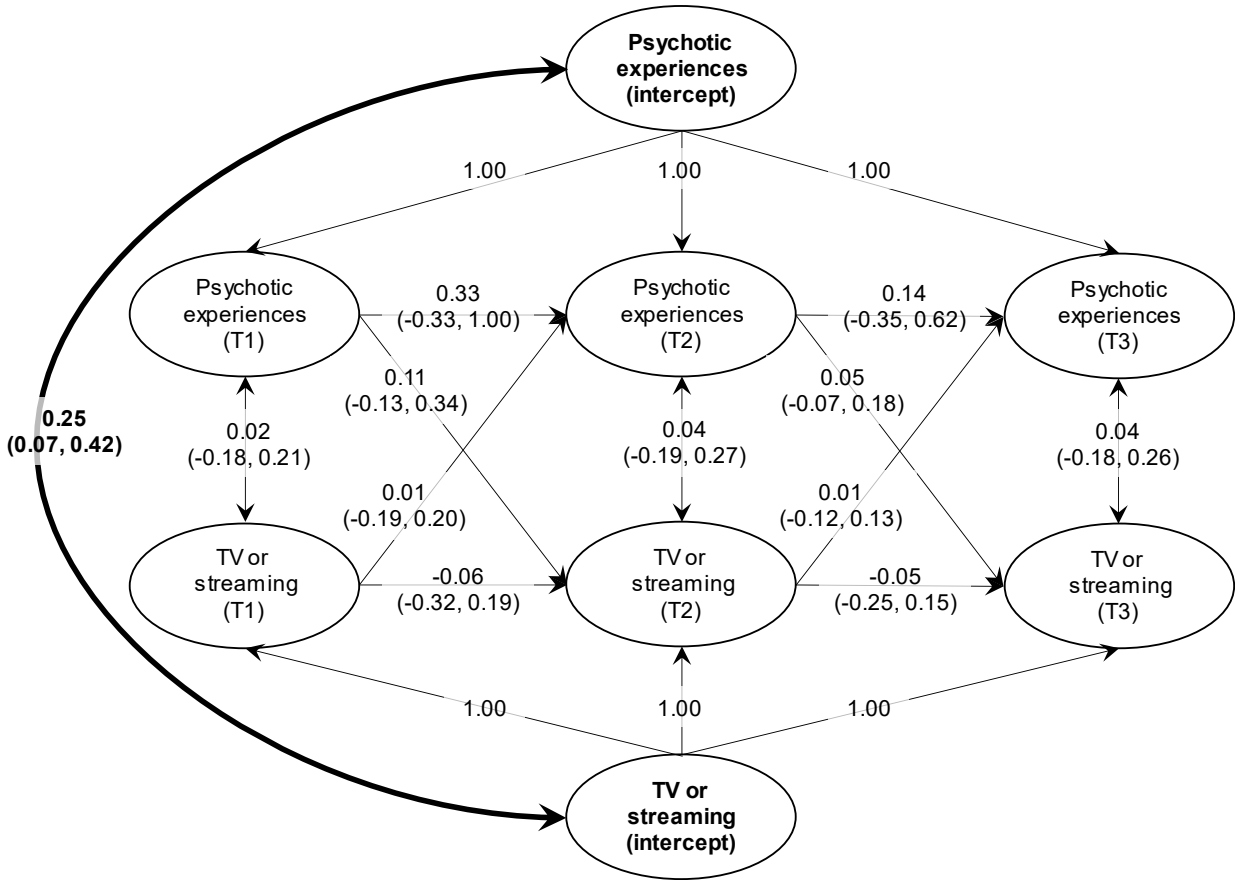
Random-intercept cross-lagged panel model, restricted to participants who completed at least 2 waves (N=263); standardized estimates (95% confidence intervals). Participants' trait propensities for psychotic experiences (up) and overall digital media use (bottom) are captured by time-varying random intercepts (in bold). The correlation between intercepts (also in bold) is thus at the between-person level. Associations among repeated measures at study waves T1, T2 and T3 are within persons. Paths from intercepts to repeated measures were constrained to 1.00. The model produced acceptable fit: $\chi^2(6)=14.36$, $p=.03$; CFI=0.986; RMSEA=0.073 (90% CI: 0.024, 0.122); SRMR=0.049.

Supplementary Figure 3. Female-only associations between overall digital media use and psychotic experiences within and between persons (standardized estimates)



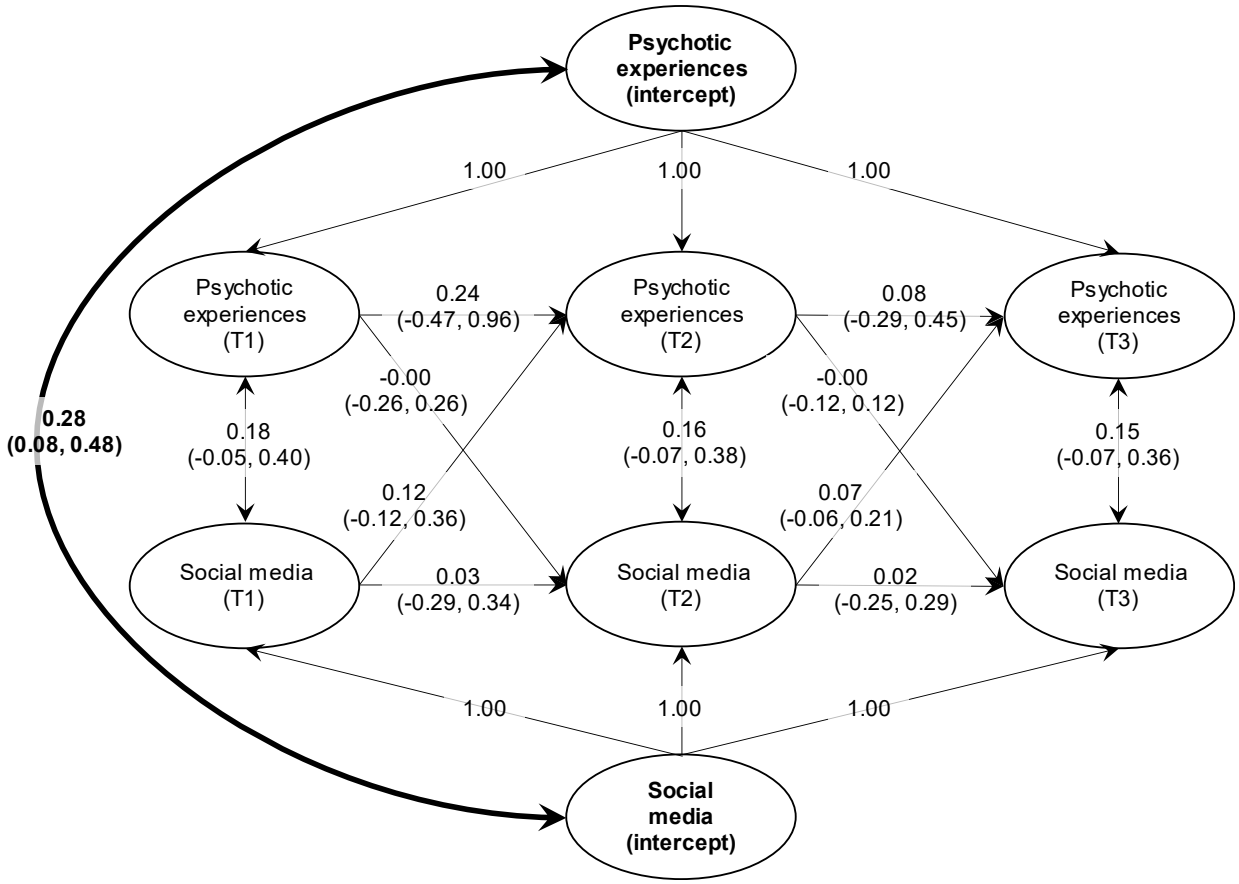
Random-intercept cross-lagged panel model, restricted to female participants (N=348); standardized estimates (95% confidence intervals). Participants' trait propensities for psychotic experiences (up) and overall digital media use (bottom) are captured by time-varying random intercepts (in bold). The correlation between intercepts (also in bold) is thus at the between-person level. Associations among repeated measures at study waves T1, T2 and T3 are within persons. Paths from intercepts to repeated measures were constrained to 1.00. The model produced acceptable fit except for RMSEA which was not satisfactory: $\chi^2(6)=21.05$, p=.002; CFI=0.966; RMSEA=0.085 (90% CI: 0.047, 0.126); SRMR=0.068.

Supplementary Figure 4. Associations between TV/streaming use and psychotic experiences within and between persons (standardized estimates)



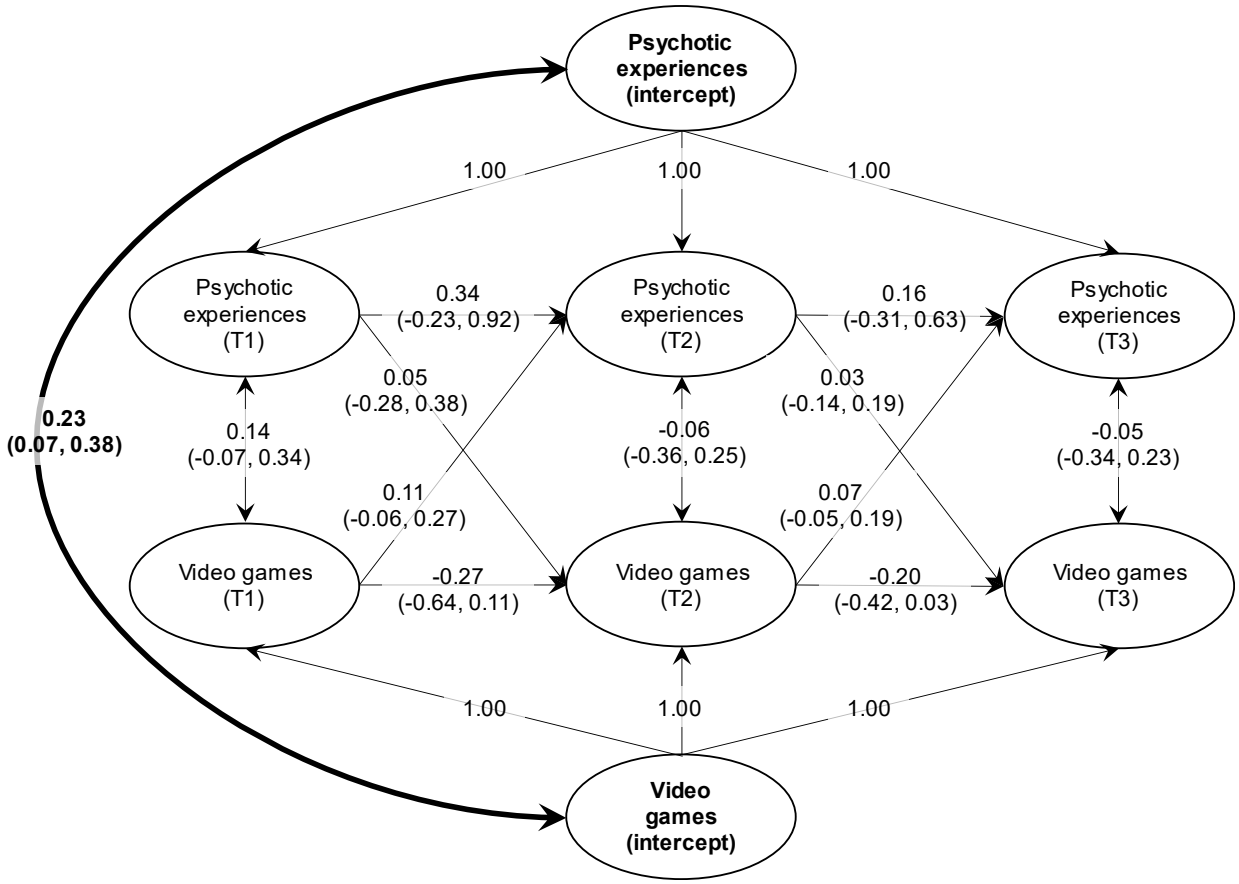
Random-intercept cross-lagged panel model (N=425), standardized estimates (95% confidence intervals). Participants' trait propensities for psychotic experiences (up) and TV/streaming service use (bottom) are captured by time-varying random intercepts (in bold). The correlation between intercepts (also in bold) is thus at the between-person level. Associations among repeated measures at study waves T1, T2 and T3 are within persons. Paths from intercepts to repeated measures were constrained to 1.00. The model produced good fit: $\chi^2(6)=8.13$, $p=.23$; CFI=0.996; RMSEA=0.029 (90% CI: 0.000, 0.074); SRMR=0.034.

Supplementary Figure 5. Associations between social media use and psychotic experiences within and between persons (standardized estimates)



Random-intercept cross-lagged panel model (N=425), standardized estimates (95% confidence intervals). Participants' trait propensities for psychotic experiences (up) and social media use (bottom) are captured by time-varying random intercepts (in bold). The correlation between intercepts (also in bold) is thus at the between-person level. Associations among repeated measures at study waves T1, T2 and T3 are within persons. Paths from intercepts to repeated measures were constrained to 1.00. The model produced good fit: $\chi^2(6)=3.66$, $p=.72$; CFI=1.000; RMSEA=0.000 (90% CI: 0.000, 0.046); SRMR=0.020.

Supplementary Figure 6. Associations between video game use and psychotic experiences within and between persons (standardized estimates)



Random-intercept cross-lagged panel model (N=425), standardized estimates (95% confidence intervals). Participants' trait propensities for psychotic experiences (up) and video game use (bottom) are captured by time-varying random intercepts (in bold). The correlation between intercepts (also in bold) is thus at the between-person level. Associations among repeated measures at study waves T1, T2 and T3 are within persons. Paths from intercepts to repeated measures were constrained to 1.00. The model produced acceptable fit: $\chi^2(6)=17.17$, p=.009; CFI=0.985; RMSEA=0.066 (90% CI: 0.031, 0.104); SRMR=0.050.

References (Supplementary Material)

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