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Within-person variability in curiosity during daily life and associations with well-being

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Abstract

Objective: Curiosity promotes engagement in novel situations and the accruement of resources that promote well-being. An open question is the extent to which curiosity lability, the degree to which curiosity fluctuates over short timescales, impacts well-being.

Method: We use data from a 21-day daily diary as well as trait measures in 167 participants (mean age = 25.37 years, *SD* = 7.34) to test (a) the importance of curiosity lability for depression, flourishing, and life satisfaction, (b) day-to-day associations among curiosity and happiness, depressed mood, anxiety, and physical activity, and (c) the role of day's mood as a mediator between physical activity and curiosity.

Results: We observe positive associations among curiosity lability and depression, as well as negative associations among curiosity lability and both life satisfaction and flourishing. Curiosity is higher on days of greater happiness and physical activity, and lower on days of greater depressed mood. We find evidence consistent with day's depressed mood and happiness being mediators between physical activity and curiosity.

Conclusions: Greater consistency in curiosity is associated with well-being. We identify several potential sources of augmentation and blunting of curiosity in daily life and provide support for purported mechanisms linking physical activity to curiosity via mood.

KEYWORDS
curiosity, daily diary, depressed mood, positive affect, well-being

1 | INTRODUCTION

Curiosity is the propensity to seek out novel, complex, and challenging interactions with the world (Kashdan & Steger, 2007; Loewenstein, 1994). Curiosity facilitates engagement with unfamiliar information (Silvia, 2008), even if that information challenges existing beliefs and instills uncertainty (Kashdan et al., 2009). States of curiosity are functional; they facilitate the coordination of physiological states associated with concentration and approach-oriented action (Libby, Lacey, & Lacey, 1973; Reeve & Nix, 1997) and they are associated with increased motivation to expand one's knowledge and skills (Ainley, Hidi, & Berndorff, 2002). Trait curiosity is positively associated with life satisfaction and well-being (Park, Peterson, & Seligman, 2004; Peterson, Ruch, Beermann, Park, & Seligman, 2007) and negatively associated with depression (Kaczmarek, Bączkowski, Enko, Baran, & Theuns, 2014; Kaczmarek et al., 2013). Curiosity's association with well-being has been interpreted within the broaden-and-build theory of positive emotions (Fredrickson, 1998; Fredrickson & Cohn, 2008), which proposes that positive emotions function to build lasting resources. Negative emotions narrow attention, cognition, and physiology, and function to facilitate responses to immediate threats. Positive emotions, in contrast, produce novel and broad-ranging thoughts and actions that typically do not play a role in one's immediate safety but, over time, the novel experiences aggregate (or build) into consequential resources that can positively impact people's lives. Curiosity, by promoting focused engagement in novel and challenging situations, results in the accruement of knowledge and social resources (Fredrickson, 2001) that promote well-being (Fredrickson, 2013; Kashdan, Rose, & Fincham, 2004).

Importantly, it is through *consistently* acting on curious feelings that high trait curiosity is theorized to build competencies and, in turn, promote well-being (Kashdan et al., 2018). Although a person scoring highly on a trait scale of curiosity (e.g., Kashdan et al., 2009) has a general disposition to explore and seek out new experiences and to accept novel and unfamiliar situations, places, and people, approaches to personality increasingly consider both trait tendencies captured through one-time scales *and* short-term deviations from these tendencies captured using intensive repeated measures designs (Fleeson, 2001; Lydon-Staley & Bassett, 2018; Nesselroade, 1991; Ram et al., 2013). These study designs repeatedly assess individuals as they go about their daily lives and are increasingly feasible due to advances in, and the ubiquity of, mobile communication technologies (Pew Research Center, 2017). When multiple observations of an individual's behavior are collected, the time series data may be interrogated to characterize at least two aspects of personality. The repeated measures data can be modeled as a combination of the individual's behavioral tendencies (a central tendency measure such as the mean of the time series) and the state variance (a variability measure such as the standard deviation of the time series). As one might expect, trait measures are positively associated with individual differences in the expression of trait-relevant states during daily life (Fleeson & Gallagher, 2009). However, there is substantial leftover state variance indicative of deviations from trait-relevant behaviors during the course of daily life. This leftover state variance not captured by the central tendency is not completely orthogonal to trait measures of personality, with higher trait levels often associated with more restricted variance (less inconsistency) around behavioral tendencies (Green et al., 2018; Paunonen, 1988). Despite some relation to behavioral tendencies, the information captured by this leftover state variance is considered to provide additional information and to be an aspect of personality in itself, capturing the range of an individual's behavior (Fleeson, 2001).

The time-varying nature of curiosity, especially its transience, has been long-noted (Loewenstein, 1994) and daily (or finer timescale) fluctuations in curiosity and their implications for the day-to-day engagement in growth-oriented behaviors are increasingly the subject of scientific investigation (Garrosa, Blanco-Donoso, Carmona-Cobo, &, Moreno-Jiménez, 2017; Kashdan & Steger, 2007; Kashdan et al., 2013). Yet, important questions remain unanswered about how fluctuations in curiosity impact well-being. We examine the extent to which curiosity lability, which we define as the extent to which curiosity fluctuates on fine timescales (see also Nesselroade, 1991; Ram & Gerstorf, 2009), is associated with well-being. From the perspective of the broaden-and-build framework, we hypothesize that the consistency of curiosity is associated with greater well-being. Relatively greater consistency in the tendency to explore and to build competencies and skills will be associated with well-being due to the consistent enactment of growth-promoting behaviors. In contrast, we hypothesize that inconsistent curiosity, reflecting relatively greater changes in the experience of curiosity from day-to-day and less consistent growth-promoting behaviors, is associated with lower well-being.

In addition to examining associations among curiosity lability and well-being, we examine potential sources of augmentation and blunting of curiosity in daily life. We focus on day-to-day associations between curiosity and one positive emotion (happiness) and two negative emotions (depressed mood, anxiety). According to the broaden-and-build theory, positive emotions serve to broaden individuals' behaviors and cognitive repertoires, allowing individuals to consider and attempt diverse and novel courses of action, including those at the core of curiosity. In line with this perspective that positive emotions motivate the drive-free exploration that characterizes curiosity (Diener & Diener, 1996), we test the hypothesis that days of higher than usual happiness are associated with higher than usual curiosity. In contrast to the proposed facilitatory role of positive emotions for curiosity, negative

emotions are thought to disrupt activities that broaden and build competencies as they function to direct actions towards the immediate situation (Fredrickson, 2004) and entail the narrowing, rather than broadening, of behavior (Fredrickson & Branigan, 2005). Indeed, mood induction experiments indicate that depressed mood reduces curiosity and the desire for knowledge (Rodrigue, Olson, & Markley, 1987). Other work highlights that anxiety may interfere with the exploratory behavior characteristic of curiosity (Kashdan et al., 2004; Reio & Callahan, 2004). Motivated by these prior studies, we test the hypotheses that days of higher than usual depressed mood and anxiety are associated with lower than usual curiosity.

Finally, we examine the association between physical activity and curiosity in daily life. Physical activity is associated with curiosity at the between-person level, with high exercisers relative to low exercisers exhibiting higher curiosity, leading to recommendations to increase physical activity in order to increase curiosity (Brand et al., 2010). Although the association between physical activity and curiosity has been observed at the between-person level, strict criteria must be met to accurately make an inference from between-person findings (people who are more physically active exhibit higher levels of curiosity) to within-person phenomena (on days when an individual is more physically active than usual they are more curious than usual). These strict criteria are rarely met (e.g., ergodicity; Molenaar, 2004). As such, we significantly extend this prior work by examining within-person processes to determine whether days of higher than usual physical activity are also days of higher than usual curiosity. Moreover, we examine the extent to which mood acts as a mediator between physical activity and curiosity in daily life due to theories positing that the association between physical activity and curiosity stems from physical activity's effects on mood, with physical activity associated with increased positive and decreased negative mood (Berger & Owen, 1992; Penedo & Dahn, 2005; Rehor, Stewart, Dunnagan, & Cooley, 2001).

2 | MATERIALS AND METHODS

We made use of data from the Knowledge Networks Over Time (KNOT) study, an intensive longitudinal study designed to provide insight into day-to-day intraindividual variability across a range of domains of functioning, in particular curiosity. Data and code used in the manuscript are available upon request from the corresponding author.

2.1 | Participants

Participants were 167 individuals (136 female, 29 male, 2 other gender) recruited through poster, Facebook, Craigslist, and university research site advertisements in Philadelphia and the surrounding university community. Individuals were eligible if they met 4 criteria: (a) aged between 18 and 65 years, (b) consistent access to a computer with internet access at home, (c) willingness to complete 21 consecutive days of surveys, (d) willing to visit the research laboratory for a 1 hr visit. Participants were aged between 18.21 and 65.24 years ($M = 25.37$, $SD = 7.34$), and identified as White (49.10%), African American/Black (8.38%), Asian (23.35%), Hispanic/Latino (4.79%), Multiracial (6.59%), other (5.39%), and missing information (2.40%). Participants identified as bisexual (7.78%), gay (4.19%), heterosexual (79.04%), lesbian (1.20%), other (5.99%), and missing information (1.80%). Participants reported a yearly family income ranging from "under $20,000" to "$200,000 or more" (*Modal income* = "$20,000–$49,000"). Participants' education spanned less than a high school degree (0.60%), high school degree (8.98%), associate's degree or some college but no degree (30.54%), college degree (37.72%), graduate or professional training (20.96%), or missing information (1.20%).

2.2 | Procedure

Interested participants encountering study advertisements were directed to a website with study information and a consent form. After confirming that participants met inclusion criteria, participants were contacted via telephone with a description of the study and an opportunity to assent or decline participation. If individuals assented, an email was sent with a baseline survey containing demographic questionnaires, the curiosity measure, the depression measure, the life satisfaction measure, and the flourishing measure used in the present study. The baseline survey contained additional scales that were not the focus of the present study. Once the baseline survey was completed, participants completed a laboratory session. At the laboratory session, participants completed additional questionnaires, received training in the daily assessment protocol, and were guided through the installation of an app necessary for an internet browsing study component that we do not report on in the present manuscript. Following the laboratory study, a 21-day diary assessment protocol was initiated. The 21-day diary assessment consisted of two components. The first was a daily diary consisting of survey questionnaires that took approximately 5 min to complete. The second came immediately after the daily diary component and was a 15 min internet browsing task (Lydon-Staley, Zhou, Blevins, Zurn, & Bassett, 2019) that we do not report on in the present manuscript. Links to the daily assessments were emailed to participants at 6:30 p.m. each evening. Participants requesting reminders received a text message at 6:40 p.m. to notify them that survey links had been emailed. Participants were instructed to complete the daily assessments before going to bed but

that links remained open until 10:00 a.m. the next morning. In cases where participants completed the surveys the following morning, they were instructed to report as if they were completing the survey on the previous evening. Daily questionnaires took approximately 5 min to complete. The median time of completion of the daily survey was 7:32 p.m. Participants were compensated with gift cards to Amazon.com at each study phase: $25 after completing the baseline assessment and the laboratory visit. For the daily assessment, completion was incentivized by making participant payment contingent on completion: completion of 3, 4, 5, 6, and 7 surveys each week was compensated with gift cards worth $10, $15, $20, $25, and $35, respectively. Continued participation through the daily assessment was further incentivized by using a raffle for which an iPad mini was available as a prize. Completion of all 7 surveys each week resulted in one entry into the raffle drawing.

2.3 | Measures

The present study made use of participants' reports of demographic and trait characteristics from the baseline surveys and their daily diary reports.

2.3.1 | Trait curiosity

Trait Curiosity was measured using the Curiosity and Exploration Inventory-II (CEI-II; Kashdan et al., 2009). The CEI-II consists of 10 items and measures two dimensions of curiosity with two subscales of 5 items each. The stretching subscale measures the extent to which an individual is motivated to seek knowledge and new experiences while the embracing subscale measures the willingness to embrace the novel, uncertain, and unpredictable nature of everyday life. Items are answered on a scale ranging from 1 (“Very slightly or not at all”) to 5 (“Extremely”). The mean value of all 10 items was taken as a measure of curiosity, with higher values indicating relatively higher levels of curiosity. For the current sample, the measure demonstrated high internal consistency ($\alpha = .88$).

2.3.2 | Flourishing

Flourishing was measured using an 8-item flourishing scale (Diener et al., 2010). The flourishing scale contains items related to important aspects of human functioning, including positive relationships, feelings of competence, and having meaning and purpose in life. Flourishing scale items are answered on a 1 (“Strong Disagreement”) to 7 (“Strong Agreement”) scale. The mean value of all 8 items was taken as a measure of flourishing, with higher values indicating relatively higher levels of flourishing. The scale demonstrated high internal consistency in the current sample ($\alpha = .90$).

2.3.3 | Life satisfaction

Life satisfaction was measured using the satisfaction with life scale (Diener, Emmons, Larsen, & Griffin, 1985). The scale consists of 5 items designed to measure global cognitive judgments of satisfaction with one's life. Items are answered on a scale that ranges from 1 (“Strongly Disagree”) to 7 (“Strongly Agree”). The mean value of all 5 items was taken as a measure of life satisfaction, with high values indicating relatively higher levels of life satisfaction. The scale demonstrated high internal consistency in the current sample ($\alpha = .89$).

2.3.4 | Depression

Depression was measured at the laboratory session using the Center for Epidemiological Studies Depression Scale (Radloff, 1977). The scale consists of 20 items. Each item is a symptom associated with depression, and participants rate how often they experienced a particular symptom in the previous week on a scale ranging from 1 (“rarely or none of the time (less than 1 day)”) to 4 (“Most or all of the time (5–7 days)”). Four items are reverse coded. The mean value of all 20 items was taken as a measure of depression, with high values indicating higher levels of depression. The scale demonstrated high internal consistency in the current sample ($\alpha = .90$).

2.3.5 | Daily curiosity

Daily curiosity was measured during the daily diary component of the study using 2-items from the CEI-II that have been used in previous studies of daily curiosity (e.g., Kashdan et al., 2013). Participants responded to the items “Today, I viewed challenging situations as an opportunity to grow and learn” and “Everywhere I went today, I was out looking for new things or experiences” on a slider ranging from 0 (“Not at all”) to 10 (“Very”) in increments of 0.1. Responses across the items were summed to form a daily curiosity scale, with higher values indicating higher levels of curiosity.

2.3.6 | Daily emotion

Daily emotion was measured using items adapted from the Profile of Mood States (Terry, Lane, & Fogarty, 2003) of the form “How much of the time today did you feel…?” that have been used in previous experience-sampling studies (Maher et al., 2013). Three emotion scales, each consisting of two items—happiness (happy, content), depression (depressed, sad or blue), and anxiety (anxious, worried)—were computed. Participants rated how much they felt each emotion that day using a slider ranging from 0 (“None of the time”) to 10 (“All of the time”) in 0.1 increments.

2.3.7 | Physical activity

Daily physical activity was measured using a modified version of the Godin Leisure Time Exercise Questionnaire (LTEQ; Godin, Jobin, & Bouillon, 1986; Godin & Shephard, 1985). The LTEQ is a validated measure of adult physical activity (Jacobs, Ainsworth, Hartman, & Leon, 1993) and a daily version of this measure has been used in previous experience-sampling studies (Maher et al., 2013). Participants were asked to rate how many times they engaged in mild exercise (e.g., easy walking, yoga), moderate exercise (e.g., fast walking, volleyball), and vigorous exercise (e.g., running, vigorous swimming). Using the LTEQ scoring procedure, responses were weighted by standard metabolic equivalents (MET; mild activity = 3, moderate activity = 5, vigorous activity = 9) and summed to create a daily MET or energy expenditure score. Higher scores indicated more physical activity energy expenditure.

2.4 | Data analysis

2.4.1 | Creating a curiosity lability index

In order to examine the importance of fluctuations in curiosity for well-being, we computed a curiosity lability score for each individual as:

$$\text{Curiosity lability}_i = \frac{\sigma_i}{\mu_i} \quad (1)$$

where $\text{curiosity lability}_i$ is the curiosity lability score for person i, σ_i is the standard deviation of the curiosity time series from the daily diary of person i, and μ_i is the mean of the curiosity time series from the daily diary of person i. Dividing the standard deviation by the mean results in the coefficient of variation, a relative index of the extent to which values of a variable are dispersed around the mean. Higher curiosity lability values indicate greater dispersion around the mean. The coefficient of variation is commonly used as a measure of intraindividual variability (e.g., Levitt et al., 2004; Shiffman et al., 2000). A participant with an outlier value on curiosity lability (6.96 standard deviations above the mean) was identified and removed from analyses that used this index.

An alternative measure of intraindividual variability is the standard deviation of each individual's time series, the intraindividual standard deviation (iSD). The iSD is an intuitive measure of intraindividual variability. However, in practice, it is often confounded with the intraindividual mean of the time series (Baird, Le, & Lucas, 2006; Eid & Diener, 1999; van Geert & van Dijk, 2002) such that when considering the associations between variability in a variable (i.e., curiosity lability) and a second variable (e.g., life satisfaction), it is possible that the average of the first variable may account for the observed association. Although there is theorized to be additional information in indices of variability beyond trait measures (Fleeson, 2001), it has long been (Paunonen, 1988), and more recently (Green et al., 2018), noted that information contained in indices of variability are unlikely to be completely orthogonal to information contained in estimates of central tendency. If a trait is relevant for understanding behavior (i.e., if an individual scores highly on a personality trait), then one would expect the individual high in that trait to more consistently demonstrate that trait across time and situations. In other words, one would hypothesize a negative association between scores on a scale measuring endorsement of a trait and variability in the trait's expression when repeatedly assessed. We find that curiosity lability as operationalized by the coefficient of variation is negatively correlated ($r(165) = -.28$, $p < .001$) with trait curiosity as measured by the CEI-II trait curiosity scale (Table 1), indicating a modest tendency for participants high in trait curiosity to show less variability in curiosity during daily life. In contrast, we observe a positive correlation between the iSD of curiosity and the CEI-II scale ($r(165) = .47$, $p < .001$), suggesting confounding with the mean. These considerations led us to use the coefficient of variation in the present study.

2.4.2 | Testing associations among curiosity lability and well-being

We then tested the extent to which curiosity lability was associated with depression, flourishing, and life satisfaction above and beyond trait curiosity (and covariates) in three separate multiple regression models (one for each outcome) of the form (using depression as an example):

$$\begin{aligned}\text{Depression}_i = {} & \beta_0 + \beta_1 \,\text{trait curiosity}_i + \beta_2 \,\text{curiosity lability}_i \\ & + \beta_3 \,\text{age}_i + \beta_4 \,\text{gender male}_i + \beta_5 \,\text{gender other}_i \\ & + \beta_6 \,\text{number of days}_i + \beta_7 \,\text{completion time}_i \quad (2)\end{aligned}$$

where β_0 is the intercept, indicating the average level of depression for the prototypical female (all predictors were sample-mean centered except for gender which was dummy coded such that female was the reference category), β_1 is the mean value of the CEI-II scale completed during the baseline survey, β_2 is the curiosity lability score created by computing the coefficient of variation on each individuals' curiosity time series from the daily diary component of the study (Equation 1), β_3 examines associations among depression and age, β_4 compares depression values for males relative to females, β_5 compares depression values for participants reporting other genders relative to females, β_6 controls for the number of days of the daily diary data completed by participants, and β_7 controls for the average time surveys were completed during the 6:30p.m. to 10:00a.m. period that they were available each day (operationalized

TABLE 1 Correlations and descriptive statistics

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Trait curiosity	–										
2. Curiosity lability	−0.28***	–									
3. CESD	−0.08	0.17*	–								
4. Life satisfaction	0.10	−0.23**	−0.50***	–							
5. Flourishing	0.29***	−0.18*	−0.54***	0.67***	–						
6. Age	0.02	−0.001	0.05	−0.25**	−0.07	–					
7. Curiosity[a]	0.39***	−0.73***	−0.15*	0.18*	0.25**	0.05	–				
8. Happiness[a]	0.10	−0.35***	−0.35***	0.38***	0.39***	−0.001	0.49***	–			
9. Depressed mood[a]	0.03	−0.03	0.59***	−0.23**	−0.32***	−0.03	0.02	−0.29***	–		
10. Anxiety[a]	0.05	−0.06	0.51***	−0.13	−0.24**	−0.11	0.001	−0.24**	0.77***	–	
11. Physical activity[a]	0.15	−0.24**	0.04	0.16*	0.17*	0.06	0.33***	0.14	0.08	0.08	–
Variables											
Mean	3.42	0.73	0.59	4.76	5.92	25.37	3.09	5.31	1.25	2.47	8.21
Standard Deviation	0.70	0.46	0.44	1.33	0.80	7.34	1.86	1.62	1.30	1.78	5.25

Abbreviation: CESD, center for epidemiological studies depression scale.

[a]Intraindividual mean of the daily diary time series; $N = 166$ for variables 1–6; $N = 167$ for variables 7–10.

***$p < .001$; **$p < .01$; *$p < .05$.

as minutes since midnight). A power analysis run using the *pwr* package in R (Champely et al., 2018) indicated that the multiple regressions were sufficiently powered to detect large effect sizes (Cohen, 1988) given our sample size ($n = 166$), significance level ($\alpha = .05$), and desired power of .80. We additionally ran models that included an interaction between trait curiosity and curiosity lability to test the extent to which the associations between curiosity lability and depression, life satisfaction, and flourishing depended on the level of trait curiosity. Non-significant interactions were not retained in the final models for depression and life satisfaction. A significant interaction for the flourishing model was followed-up using the Johnson-Neyman technique (Bauer & Curran, 2005).

2.4.3 | Identifying factors associated with day-to-day variability in curiosity

Once we observed associations among fluctuations in curiosity and well-being, we turned to our next research question concerning the factors associated with day-to-day variability in curiosity. A multilevel model framework was adopted to accommodate the nested nature of the intensive repeated measures data (21 days nested within 167 persons). In order to facilitate a focus on within-person associations among curiosity and happiness, depressed mood, anxiety, and physical activity, the predictor variables were parameterized to separate within-person and between-person associations by creating time-invariant (between-person) and time-varying (within-person) versions of the predictor variables (see Bolger & Laurenceau, 2013). We calculated the time-invariant, between-person variables for *usual happiness*, *usual depressed mood*, *usual anxiety*, and *usual physical activity* as the grand-mean centered individual mean score of happiness, depressed mood, anxiety, and physical activity, respectively, across all days in the daily diary study. Participants with positive values on these between-person variables had greater than usual levels of happiness, depressed mood, anxiety, and physical activity throughout the study compared with other participants in the sample. Participants with negative values on these variables had lower levels of happiness, depressed mood, anxiety, and physical activity. We calculated time-varying, within-person versions of the happiness, depressed mood, anxiety, and physical activity variables as deviations from these between-person means and, thus, (a) zero on these within-person variables indicated days of usual levels of happiness, depressed mood, anxiety, and physical activity, (b) negative values indicated days of less than usual levels of happiness, depressed mood, anxiety, and physical activity, and (c) positive values indicated days of more than usual levels of happiness, depressed mood, anxiety, and physical activity for each individual. The physical activity variable was slid forward by one day (as the question was phrased to measure previous day's physical activity) such that the within-person physical activity variable represented physical activity on a concurrent day to the reports of curiosity.

At level 1 (day-level variables) the formal model equation was constructed as:

$$\begin{aligned}\text{Curiosity}_{it} = {} & \beta_{0i} + \beta_{1i}\,\text{day's happiness}_{it} + \beta_{2i}\,\text{day's depressed mood}_{it} \\ & + \beta_{3i}\,\text{day's anxiety}_{it} + \beta_{4i}\,\text{day's physical activity}_{it} \\ & + \beta_{5i}\,\text{day's completion time}_{it} + \beta_{6i}\,\text{day of the study}_{it} + e_{it},\end{aligned} \tag{3}$$

where curiosity_{it} is curiosity for person i on day t; β_{0i} indicates the expected curiosity on a typical day for the prototypical female (day of study was centered at 10.5 and female was the reference gender category); β_{1i} indicates within-person differences in curiosity associated with differences in day's happiness; β_{2i} indicates differences in curiosity associated with differences in day's depressed mood; β_{3i} indicates differences in curiosity associated with differences in day's anxiety; β_{4i} indicates differences in curiosity associated with differences in day's physical activity; β_{5i} indicates the effect of time of daily survey completion on curiosity; β_{6i} indicates the effect of day in the study on curiosity in order to account for time as a third variable (Bolger & Laurenceau, 2013). Finally, e_{it} are day-specific residuals that were allowed to autocorrelate (AR1).

Person-specific intercepts and associations (from Level 1) were specified (at Level 2) as:

$$\begin{aligned}\beta_0 = {} & \gamma_{00} + \gamma_{01}\,\text{usual happiness}_i + \gamma_{02}\,\text{usual depressed mood}_i + \gamma_{03}\,\text{usual anxiety}_i \\ & + \gamma_{04}\,\text{usual physical activity}_i + \gamma_{05}\,\text{usual completion time}_i + \gamma_{06}\,\text{age}_i + \gamma_{07}\,\text{gender male}_i \\ & + \gamma_{08}\,\text{gender other}_i + u_{0i}, \\ \beta_1 = {} & \gamma_{10} + u_{1i}, \\ \beta_2 = {} & \gamma_{20} + u_{2i}, \\ & \ldots \\ \beta_6 = {} & \gamma_{60},\end{aligned} \tag{4}$$

where γ denotes a sample-level parameter and u denotes residual between-person differences that may be correlated, but are uncorrelated with e_{it}. Parameters γ_{01} to γ_{08} indicate how between-person differences in the usual level of curiosity across the daily diary protocol were associated with usual levels of happiness, depressed mood, anxiety, physical activity, average daily survey completion time, participant age, and participant gender. The multilevel model was fit with SAS 9.3 PROC MIXED (Littell, Milliken, Stroup, & Wolfinger, 2006) using maximum likelihood estimation, and incomplete data was treated using assumptions of being missing at random. Assumptions of data missing at random were probed by calculating the correlation between the number of days available per participant and key study variables. The number of days available was not significantly correlated with any of the baseline variables (trait curiosity; depression; life satisfaction; flourishing; age; all p values $> .05$). The number of days available was not associated with curiosity lability or, taking the average of the daily diary variables, with usual curiosity, happiness, depressed mood, or physical activity (all p values $> .05$). Participants reporting more anxiety across the daily diary missed fewer daily diary days ($r(165) = -.17$, $p = .03$). We include number of daily diary days available in our models to control for potential effects of missing data.

It was assumed that the time-varying predictor variables were stable over time (i.e., that the data were weakly stationary). The Kwaitkowski-Phillips-Schmit-Shin test from the *tseries* package in R (Trapletti & Hornik, 2011) was used to examine the extent to which the data met this assumption of stationarity. The time series of the vast majority of participants met the assumption of weak stationarity for happiness (97.01%), depressed mood (94.61), anxiety (96.41%), and physical activity (96.41%). Further, only two individuals (1.20% of the sample) exhibited time series that did not meet the assumption of weak stationarity on more than one of the temporal variables, suggesting that the assumption of weak stationarity was reasonable.

Using existing daily diary data (Lydon-Staley, Xia, Mak, & Fosco, 2019), we followed procedures for power analysis in intensive longitudinal studies (Bolger, Stadler, & Laurenceau, 2011) and find that with a sample of 151 participants with 21 days of data (the number of observations available in the previous dataset), a significant within-person association between happiness and depression is observed in over 95% of 1,000 simulated samples. As such, the current sample of 167 should be adequately powered to detect associations between curiosity and mood. Statistical significance was evaluated at $\alpha = .05$.

2.5 | Mood as a mediator between physical activity and curiosity

To examine whether physical activity's effects on curiosity were mediated via physical activity's effects on mood, we used a within-person (1-1-1) mediation model (Bauer, Preacher, & Gil, 2006). As the focus was on within-person associations (on days when physical activity is higher than usual for an individual, is that individual's curiosity also higher than usual?), all three variables were split into time-invariant and time-varying components (Bolger & Laurenceau, 2013). We calculated the time-invariant, between-person variables for *usual happiness*, *usual depressed mood*, *usual physical activity*, and *usual curiosity* as the grand-mean

centered individual mean score of curiosity, happiness, depressed mood, and physical activity, respectively, across all days in the daily diary component of the study. We calculated time-varying, within-person curiosity, happiness, depressed mood, and physical activity variables as deviations from these between-person means. After splitting, the time-invariant components (between-person differences) were set aside and the time-varying components (day-to-day within-person changes) were examined using a multilevel mediation model.

The within-person mediation models are conceived of as two Level 1 regression equations: one where the mediator variable (using the model with happiness as an example), $M_{it} = \text{Happiness}_{it}$, is regressed on the causal variable, $X_{it} = \text{physical activity}_{it}$,

$$\text{Happiness}_{it} = 0 + a_i \,\text{physical activity}_{it} + e_{Mit}, \tag{5}$$

and one where the outcome variable, $Y_{it} = \text{curiosity}_{it}$, is regressed on the mediator variable, M_{it}, and the causal variable, X_{it},

$$\text{Curiosity}_{it} = 0 + b_i \text{happiness}_{it} + c'_i \,\text{physical activity}_{it} + e_{Yit}, \tag{6}$$

where a_i, b_i, c'_i are person-specific regression coefficients that indicate the unique within-person associations, and the zero is included to make explicit that between-person differences in baseline levels were set aside. The person-specific coefficients are modeled at Level 2 as

$$\begin{aligned} a_i &= \gamma_{a0} + u_{ai}, \\ b_i &= \gamma_{b0} + u_{bi}, \\ c'_i &= \gamma_{c'0} + u_{c'i}, \end{aligned} \tag{7}$$

where γ_{a0}, γ_{b0}, and γ_{c0} indicate the prototypical within-person associations among the three variables, and u_{ai}, u_{bi}, $u_{c'i}$ are residual unexplained between-person differences in the extent of within-person associations that are assumed to be normally distributed with zero means and a full covariance structure, $\sim N\left(0, \Sigma_G\right)$.

In practice, Equations 5 through 7 are combined and estimated simultaneously in a single multilevel model using data that are restructured so that the two outcome variables (mediator $M_{it} = \text{Happiness}_{it}$ and outcome $Y_{it} = \text{Curioisty}_{it}$) are collected into a single repeated-measures variable, Z_{it}, along with dummy indicators, S_{mi} and S_{yi}, that indicate whether the specific observation of Z_{it} belongs to the mediator or outcome variable and that serve to "turn on" and "turn off" specific parameters for each row in the data (see Bauer et al., 2006; Bolger & Laurenceau, 2013; MacCallum, Kim, Malarkey, & Kiecolt-Glaser, 1997). Using this setup, two separate mediation models (one with happiness as a mediator and another with depressed mood as a mediator) were estimated using SAS 9.3 PROC MIXED (Littell et al., 2006).

In multilevel mediation, the average indirect effect is given as

$$E\left(a_i b_i\right) = ab + \sigma_{ai,bi}, \tag{8}$$

where a is the average effect of the causal variable (day's physical activity) on the mediator (day's happiness), b is the average effect of the mediator variable (day's happiness) on the outcome variable (day's curiosity), and $\sigma_{ai,bi}$ is the covariance between the two random effects (Kenny, Korchmaros, & Bolger, 2003). The average total effect can be expressed as

$$E\left(a_i b_i + c'_i\right) = ab + \sigma_{ai,bi} + c', \tag{9}$$

where c' is the unmediated portion of the physical activity to curiosity association for the typical participant. Estimates of the average indirect effect and average total effect were estimated using the IndTest macro (https://ww.quantpsy.org/medn.htm).

3 | RESULTS

We provide descriptive statistics for the variables used in the analyses in Table 1. Out of a possible total of 3,507 daily diary days (21 days × 167 participants), 3,141 (89.56%) were available. The number of daily diary days available per participant ranged from 11 to 21 ($M = 18.81$, $SD = 2.75$).

3.1 | Curiosity lability and associations with well-being above and beyond trait curiosity

We sought to test the importance of consistency in curiosity for well-being. We used multiple regression analysis (Table 2) to test if curiosity lability was positively associated with depressive symptoms, above and beyond trait curiosity and covariates (age, gender, number of days of the daily diary protocol that were completed, and average time of daily survey completion). The results indicate that the predictors explain 9% of the variance in depressive symptoms as assessed during the baseline session ($R^2 = 0.09$, $F[7, 158] = 2.26$, $p = .03$). Curiosity lability is positively associated with depression ($B = 0.16$, $p = .04$) such that participants with relatively high day-to-day variation around their mean in their daily diary reports of curiosity also reported greater symptoms of depression (Figure 1a). Notably, trait curiosity is not uniquely associated with symptoms of depression ($B = -0.02$, $p = .74$). Age, number of days of daily diary data available, and average daily survey completion time are not associated with depression (all p values $> .05$). Participants self-identifying as

TABLE 2 Results of the multiple regression analyses examining associations between curiosity lability and depression, life satisfaction, and flourishing

	Estimate	Standard error	*p* value
Depression			
Intercept	0.64***	0.16	<.001
Trait curiosity	−0.02	0.05	.74
Curiosity lability	0.16*	0.08	.04
Age	0.005	0.005	.31
Gender male	0.07	0.09	.42
Gender other	0.83**	0.31	.008
Number of days	−0.02	0.01	.19
Completion time	−0.0001	0.0002	.64
R^2	0.09		
F	2.26*		
Flourishing			
Intercept	5.51***	0.29	<.001
Trait curiosity	0.20*	0.09	.03
Curiosity lability	−0.16	0.14	.24
Trait × lability	0.41**	0.15	.01
Age	−0.01	0.008	.31
Gender male	−0.38*	0.16	.01
Gender other	−0.68	0.53	.20
Number of days	−0.03	0.02	.21
Completion time	0.001	0.0003	.06
R^2	0.20		
F	4.90***		
Life satisfaction			
Intercept	3.71***	0.48	<.001
Trait curiosity	0.03	0.15	.82
Curiosity lability	−0.71**	0.22	.002
Age	−0.05***	0.01	<.001
Gender male	−0.42	0.26	.11
Gender other	−0.72	0.89	.42
Number of days	−0.03	0.04	.43
Completion time	0.001*	0.0005	.02
R^2	0.17		
F	4.49***		

Notes: All predictors were sample-mean centered. Gender was a factor variable with female as the reference category.
***$p < .001$; **$p < .01$; *$p < .05$. $N = 166$.

other gender reported more depression relative to females ($B = 0.83$, $p = .008$).

We used multiple regression analysis to test if curiosity lability was negatively associated with flourishing, above and beyond trait curiosity and covariates. Results indicate that the predictors explain 20% of the variance in flourishing ($R^2 = 0.20$, $F[8, 157] = 4.90$, $p < .001$). We observed a significant interaction between curiosity lability and trait curiosity ($B = 0.41$, $p = .006$). Following up the interaction, we find that curiosity lability's association with flourishing is significant for participants with below average values of trait curiosity (Figure 1c). More specifically, simple slopes of the association between curiosity lability and flourishing are significant at values below −0.27 on the sample-mean centered trait curiosity scores ($M = 0$, min = −2.02, max = 1.48). This relation is shown in Figure 1d where the slope between curiosity lability and flourishing is negative for participants with low trait curiosity (−1 *SD* below the mean; $B = -0.45$, $p = .004$) but not significant for participants with above average levels of trait curiosity (+1 *SD* above the mean; $B = -0.13$, $p = .51$). Age, number of days of daily diary data available, and average daily survey completion time are not associated with flourishing (all *p* values > .05). Males report lower flourishing relative to females ($\beta = -.38$, $p = .01$).

We used multiple regression analysis to test if curiosity lability was negatively associated with life satisfaction, above and beyond trait curiosity and covariates. The predictors explain 17% of the variance in life satisfaction ($R^2 = 0.17$, $F(7, 158) = 4.49$, $p < .001$). Curiosity lability is negatively associated with life satisfaction ($B = -0.71$, $p = .002$), such that participants with relatively high day-to-day variation around their mean daily reports of curiosity report less life satisfaction (Figure 1b). Notably, trait curiosity is not uniquely associated with life satisfaction ($B = 0.03$, $p = .82$). Neither gender nor number of days of daily diary data available is associated with life satisfaction (all *p* values > .05). Age is negatively associated with life satisfaction ($\beta = -.05$, $p = .001$), such that older participants report lower life satisfaction. The average survey completion time was significantly associated with life satisfaction ($B = 0.001$, $p = .02$).

3.2 | Associations with day-to-day variability in curiosity

Based on our findings that curiosity lability is important for well-being, we examine the factors associated with day-to-day, within-person variability in curiosity during the course of daily life (Table 3). Days of higher than usual curiosity are also days of higher than usual happiness ($\gamma_{10} = 0.34$, $p < .001$), lower than usual depressed mood ($\gamma_{20} = -0.10$, $p = .003$), and higher than usual physical activity ($\gamma_{40} = 0.02$, $p < .001$). Day's anxiety is not significantly associated with day's curiosity ($\gamma_{30} = 0.05$, $p = .06$). Person-level characteristics associated with higher than usual levels of curiosity across the 21 days of the daily diary protocol included higher than usual happiness ($\gamma_{01} = 0.53$, $p < .001$), higher than usual physical activity ($\gamma_{04} = 0.08$, $p < .001$), and age ($\gamma_{06} = 0.03$, $p = .04$). Usual levels of depressed mood, anxiety, or gender are not associated with usual levels of curiosity in daily life (all *p* values > .05).

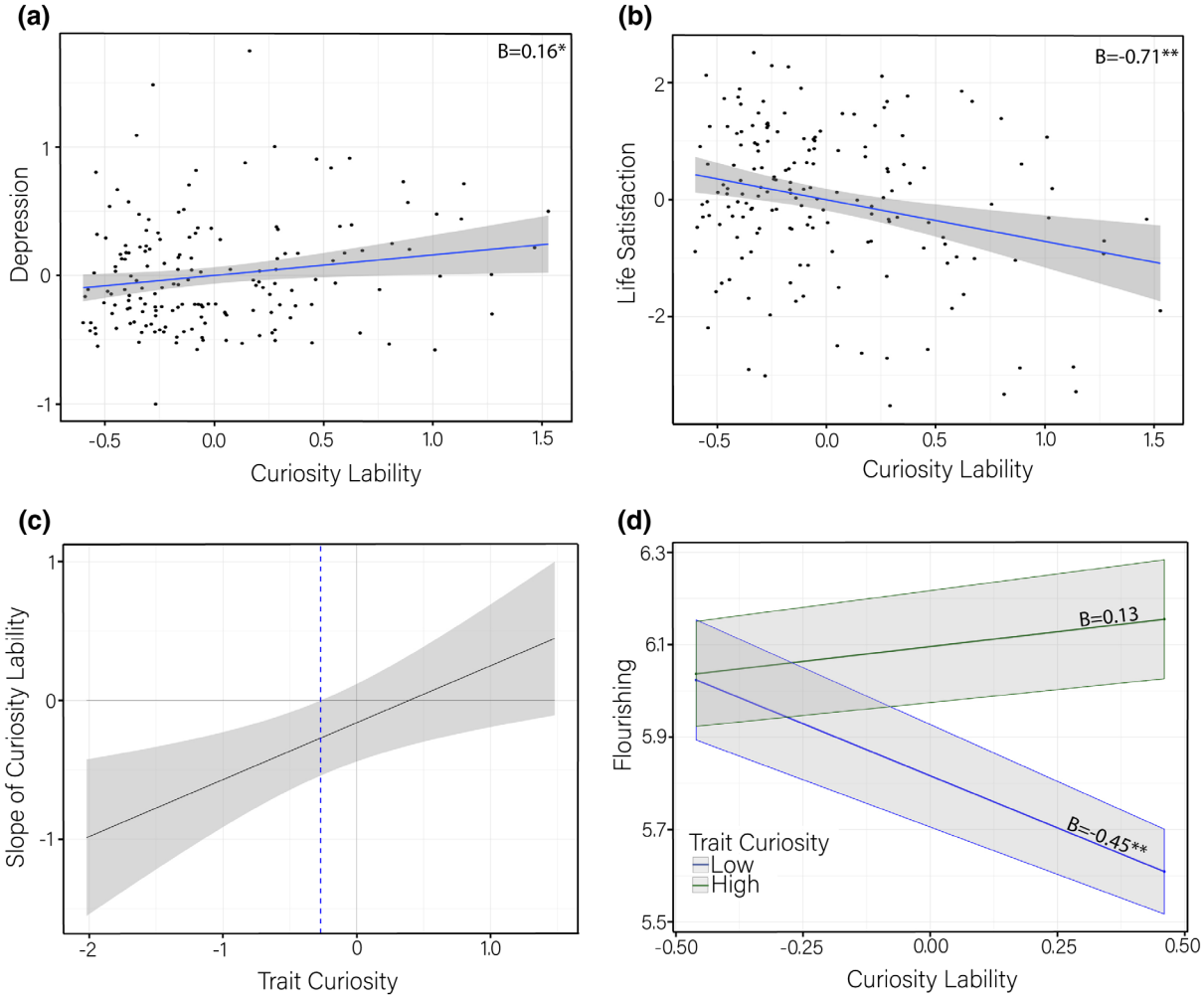

FIGURE 1 Partial residual plots show the positive association between curiosity lability and depression (a) and the negative association between curiosity lability and life satisfaction (b). The estimated associations are indicated in the top right corner of each panel. Panel C illustrates the values of sample-mean centered trait curiosity (values below the dashed blue line at −0.27) at which the association between curiosity lability and flourishing is significant. As shown in Panel D, greater curiosity lability is associated with lower flourishing for participants with low trait curiosity (−1 *SD* below the mean) but there is no significant association between curiosity lability and flourishing in participants with high trait curiosity (+1 *SD* above the mean). *Notes:* $^{**}p < .01$, $^{*}p < .05$ [Color figure can be viewed at wileyonlinelibrary.com]

3.3 | Physical activity's positive association with curiosity is partially mediated via physical activity's association with depressed mood and happiness

Based on the finding that day's physical activity is associated with day's curiosity, we examined whether physical activity's association with happiness and depressed mood could explain this association. We present the results from the mediation model examining within-person associations among physical activity, happiness, and curiosity in Table 4 and in Figure 2a. There are significant associations between physical activity and happiness ($\gamma_{a0} = 0.04$, $p < .001$), happiness and curiosity ($\gamma_{b0} = 0.35$, $p < .001$), and physical activity and curiosity ($\gamma_{c'0} = 0.03$, $p < .001$). The associations are in the expected direction, with greater than usual physical activity associated with greater than usual happiness, greater than usual happiness associated with greater than usual curiosity, and greater than usual physical activity associated with greater than usual curiosity. The average indirect effect is 0.012 ($SE = 0.003$, $p < .001$) and the estimated average total effect of physical activity on curiosity is 0.038 ($SE = 0.01$, $p < .001$). Findings are consistent with partial mediation, with 32% of the association between physical activity and curiosity mediated through physical activity's association with happiness.

Results from the mediation model examining within-person associations among physical activity, depressed mood, and curiosity are in Table 5 and in Figure 2b. There are significant associations between physical activity and depressed mood ($\gamma_{a0} = -0.01$, $p = .003$), depressed mood and curiosity

TABLE 3 Results of the multilevel model examining day-to-day associations with curiosity

	Estimate	Standard error	*p* value
Fixed effects			
Intercept (γ_{00})	3.06***	0.13	<.001
Day's happiness (γ_{10})	0.34***	0.02	<.001
Day's depressed mood (γ_{20})	−0.10**	0.03	.003
Day's anxiety (γ_{30})	0.05	0.02	.06
Day's physical activity (γ_{40})	0.02***	0.01	<.001
Day's completion time (γ_{50})	−0.001	0.001	.33
Day of the study (γ_{60})	−0.002	0.01	.74
Usual happiness (γ_{01})	0.53***	0.07	<.001
Usual depressed mood (γ_{02})	0.11	0.13	.40
Usual anxiety (γ_{03})	0.08	0.10	.39
Usual physical activity (γ_{04})	0.08***	0.02	<.001
Usual completion time (γ_{05})	−0.0001	0.0001	.40
Age (γ_{06})	0.03*	0.01	.04
Gender male (γ_{07})	0.23	0.29	.43
Gender other (γ_{08})	−0.16	1.02	.88
Random effects			
Intercept (σ^2_{u0})	2.19	0.27	
Day's happiness (σ^2_{u1})	0.03	0.01	
Day's depressed mood (σ^2_{u2})	0.01	0.01	
Day's anxiety (σ^2_{u3})	0.01	0.01	
Day's physical activity (σ^2_{u4})	0.001	0.0005	
AR(1)	0.25	0.02	
Residual (σ^2_e)	2.40	0.08	
Fit indices			
AIC	10,610.50		
BIC	10,663.50		

Notes: $N = 2{,}737$ days nested within 167 participants. Age was sample-mean centered. Female was the reference category for gender.
***$p < .001$; **$p < .01$; *$p < .05$.

($\gamma_{b0} = -0.23$, $p < .001$), and physical activity and curiosity ($\gamma_{c'0} = 0.03$, $p < .001$). The associations are in the expected direction, with greater than usual physical activity associated with lower than usual depressed mood, greater than usual depressed mood associated with lower than usual curiosity, and greater than usual physical activity associated with greater than usual curiosity. The estimated average indirect effect is 0.004 ($SE = 0.002$, $p = .04$) and the estimated average total effect of physical activity on curiosity is 0.037 ($SE = 0.01$, $p < .001$). Thus, the findings are consistent with a partial mediation account, with about 11% of the association between physical activity and curiosity mediated through reductions in depressed mood.

4 | DISCUSSION

Curiosity promotes engagement with novel and challenging stimuli and situations, leading to the accruement of resources, and promoting well-being (Fredrickson & Cohn, 2008). It is through consistently acting on one's curiosity that high trait curiosity is thought to promote well-being (Kashdan et al., 2018), necessitating a consideration of the extent to which curiosity lability, fluctuations in curiosity over the time scale of days, and a measure of inconsistency in one's curiosity, may undermine well-being. We quantified between-person differences in curiosity lability over the course of 21 days and tested the associations between curiosity lability and depression, life satisfaction, and flourishing. Consistent with the hypothesized importance of consistent curiosity in promoting well-being, individuals with relatively greater fluctuations in curiosity around their average level of curiosity during the daily diary protocol had decreased life satisfaction and increased depression. Notably, the association between curiosity lability and both life satisfaction and depression was significant above and beyond a trait measure of curiosity, indicating the added value of considering dynamics in curiosity for understanding well-being. A main effect of curiosity lability on flourishing was not observed. Instead, inconsistency in curiosity was associated with lower flourishing only for participants with below average levels of trait curiosity.

After revealing the importance of within-person fluctuations in curiosity for well-being, we examined the extent to which happiness, depressed mood, anxiety, and physical activity acted as potential sources of augmentation and blunting of curiosity in daily life. In line with previous laboratory findings (Rodrigue et al., 1987) and perspectives that positive emotions motivate exploration (Diener & Diener, 1996) while negative emotions restrict exploration (Fredrickson, 2004), we observed that days of higher than usual depressed mood were associated with lower than usual curiosity, and that days of higher than usual happiness were associated with higher than usual curiosity. These results suggest that negative associations among depressed mood and curiosity generalize to ecologically valid, naturalistic fluctuations in mood and curiosity occurring during the course of daily life.

Within-person variability in anxiety was not associated with changes in curiosity. Due in great part to the Latin

TABLE 4 Mediation model examining the within-person associations among physical activity, happiness, and curiosity

	Estimate	Standard Error	*p* value
Fixed effects			
Physical activity → happiness (γ_{a0})	0.04***	0.01	<.001
Happiness → curiosity (γ_{b0})	0.35***	0.02	<.001
Physical activity → curiosity ($\gamma_{c'0}$)	0.03***	0.01	<.001
Random effects			
Physical activity → happiness ($\sigma^2_{u_{ai}}$)	0.002	0.001	
Happiness → curiosity ($\sigma^2_{u_{bi}}$)	0.04	0.01	
Physical activity → curiosity ($\sigma^2_{u_{c'i}}$)	0.001	0.001	
Covariance (r_{uaub})	−0.0004	0.002	
Covariance ($r_{uauc'}$)	0.001	0.001	
Covariance ($r_{ubuc'}$)	0.002	0.002	
Residual curiosity (σ^2_{eY})	2.19	0.06	
Residual happiness (σ^2_{eM})	3.01	0.08	
Fit indices			
AIC	20,917.40		
BIC	20,941.40		

Notes: $N = 2{,}737$ days nested within 167 participants.
***$p < .001$.

sense of *cura* as meticulous, painstaking, even obsessive care (Leigh, 2013), curiosity and anxiety have been densely intertwined historically, promulgating the notion that curiosity "has always an appearance of giddiness, restlessness, and anxiety" (Burke, 1958, p. 31). Early psychological theories proposed that curiosity may result from the identification of contradictions and ambiguities that leads to an unpleasant feeling some have interpreted as anxiety (Berlyne, 1960; Dollard & Miller, 1950; Spielberger & Starr, 1994). Other perspectives view anxiety as a state that interferes with the exploratory behavior characteristic of curiosity (Kashdan et al., 2004). The contrasting associations among anxiety and curiosity may be differentially present prior to curiosity-driven exploration and during the process of curiosity-driven engagement with novel stimuli and situations. Testing these distinct pathways will require repeated measures at more fine-grained timescales than were available in the daily diary reports in the present study.

We replicate previously observed between-person associations among curiosity and physical activity (Brand et al., 2010), with higher levels of average physical activity across the 21-day daily diary protocol associated with higher levels of average curiosity. In addition to replicating this between-person finding, our collection of intensive repeated measures allowed us to disentangle within-person and between-person associations among physical activity and curiosity, and to demonstrate that the association among physical activity and curiosity was also evident at the within-person level, with days of greater than usual physical activity being associated with greater than usual curiosity. Results of the within-person mediation analyses are consistent with frameworks suggesting that physical activity's association with curiosity is partially mediated via physical activity's effects on positive and depressed mood (Berger & Owen, 1992; Penedo & Dahn, 2005; Rehor et al., 2001). Further study of physical activity using modes, scales, and intensities titrated to disabled bodies, moreover, could deepen and extend the present study to account for a population significantly understudied in the literature on curiosity.

5 | LIMITATIONS AND FUTURE DIRECTIONS

It is important to consider the findings in light of the study's strengths and limitations. We work within a theoretical framework that proposes that consistent curiosity causes flourishing and life satisfaction as well as resilience against depression by promoting focused engagement in novel and challenging situations that, over time, result in the accruement of knowledge and social resources (Fredrickson, 2001) that promote well-being (Fredrickson, 2013; Kashdan et al., 2004). Despite the promising initial findings, causality can only be established by manipulating curiosity in laboratory or intervention experiments. It is plausible that the opposite directional association also exists such that depression, low flourishing, and low life satisfaction cause low and inconsistent curiosity. Cross-lagged panel designs will help assess the plausibility of these two potential causal pathways between curiosity and well-being.

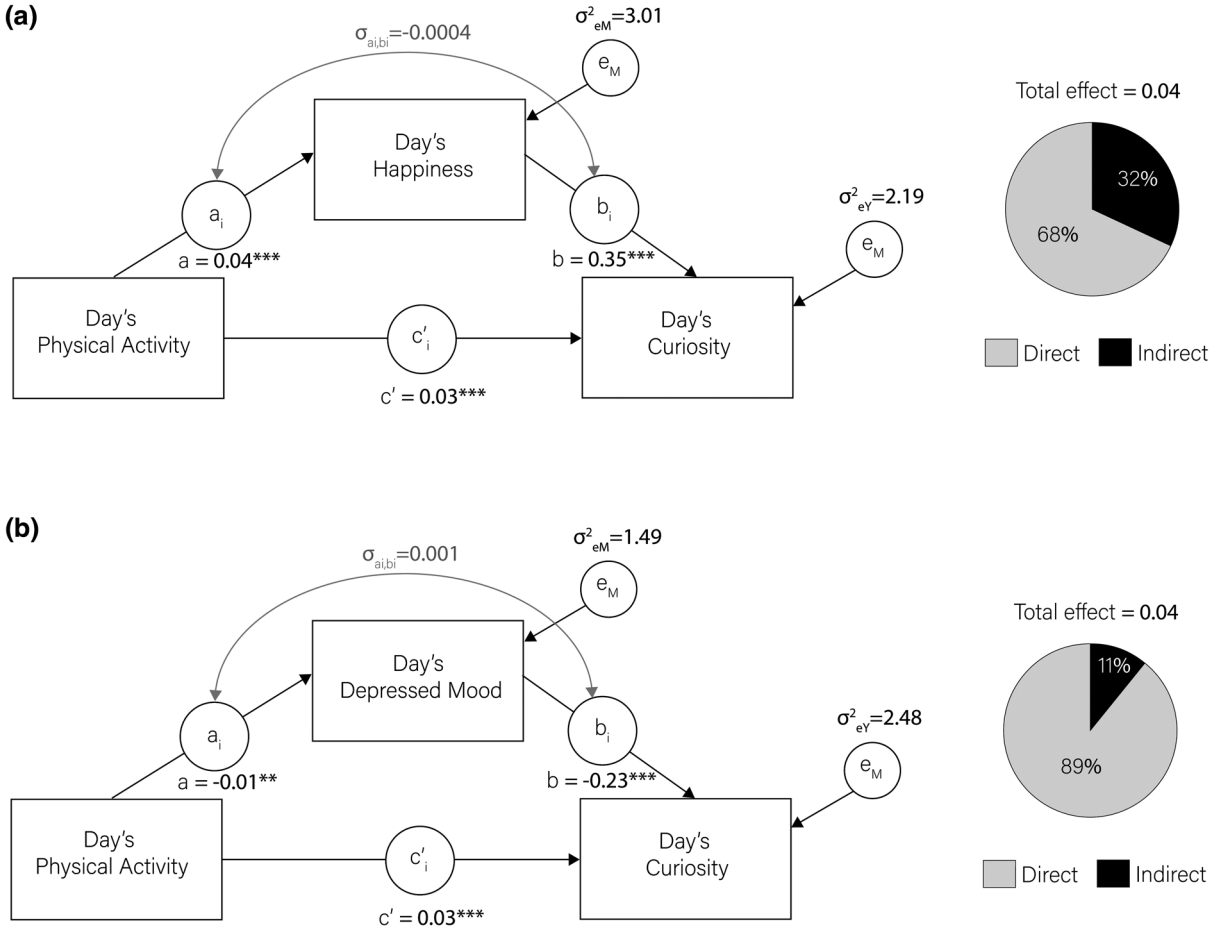

FIGURE 2 Results of the within-person mediation models. Panel A indicates that days of higher than usual physical activity were associated with higher than usual happiness (a) and higher than usual curiosity (c′) and that days of higher than usual happiness were associated with days of higher than usual curiosity (b). The pie chart illustrates the portion of the effect of day's physical activity on curiosity accounted for by happiness based on Equations 8 and 9 in the main text. Panel B indicates that days of higher than usual physical activity were associated with lower than usual depressed mood (a) and lower than usual curiosity (c′) and that days of higher than usual depressed mood were associated with lower than usual curiosity (b). The pie chart illustrates the portion of the effect of day's physical activity on curiosity accounted for by depressed mood based on Equations 8 and 9 in the main text

Our use of daily diaries allowed us to capture naturally-occurring variation in curiosity during life as it is lived (Bolger, Davis, & Rafaeli, 2003). However, the daily diary data are limited in their ability to evaluate temporal precedence, and the need to complete the surveys on computers rather than more portable devices (e.g., smartphones; von Stumm, 2018) did not allow in-the-moment ratings of experience. Nevertheless, we note that daily retrospective assessments of affect provide insights into day-to-day fluctuations in affect that are similar to those obtained from aggregated momentary ratings (Neubauer, Scott, Sliwinski, & Smyth, 2019). Future work, drawing on multiple occasions (3 or more) each day via portable devices, will provide opportunities to examine putative causal associations and to provide more stringent tests of mediation. In the current manuscript, due to our goal of identifying potential sources of augmentation and blunting of curiosity in daily life, we specify a within-person causal pathway from physical activity to curiosity via mood. Due to the correlational nature of the data, we cannot rule out an alternative pathway from day's curiosity to day's physical activity, for example. Indeed, given that curiosity encourages exploration, a path from curiosity to physical activity is plausible. The collection of more intensive momentary reports of curiosity and physical activity coupled with emerging analysis techniques (Lydon-Staley, Barnett, Satterthwaite, & Bassett, 2019) will allow the testing of potential bidirectional associations among curiosity and physical activity.

We focused on potential positive aspects of curiosity and its consistent experience during daily life. Although our results are in line with previous work indicating associations with positive well-being, curiosity may also play a role in behaviors associated with more negative outcomes such as substance use (Jovanović & Gavrilov-Jerković, 2014; Lindgren, Mullins, Neighbors, & Blayney, 2010; Pierce, Distefan, Kaplan, & Gilpin, 2005), requiring research that asks for whom, and under what conditions, does curiosity lead to positive and negative outcomes.

TABLE 5 Mediation model examining the within-person associations among physical activity, depressed mood, and curiosity

	Estimate	Standard error	*p* value
Fixed effects			
Physical activity → depressed mood (γ_{a0})	-0.01^{**}	0.005	.003
Depressed mood → curiosity (γ_{b0})	-0.23^{***}	0.03	<.001
Physical activity → curiosity ($\gamma_{c'0}$)	0.03^{***}	0.01	<.001
Random effects			
Physical activity → depressed mood ($\sigma^2_{u_{ai}}$)	0.001	0.0003	
Depressed mood → curiosity ($\sigma^2_{u_{bi}}$)	0.05	0.02	
Physical activity → curiosity ($\sigma^2_{u_{c'i}}$)	0.002	0.001	
Covariance (r_{uaub})	0.001	0.001	
Covariance ($r_{uauc'}$)	0.0001	0.0003	
Covariance ($r_{ubuc'}$)	−0.003	0.003	
Residual curiosity (σ^2_{eY})	2.48	0.07	
Residual depressed mood (σ^2_{eM})	1.49	0.04	
Fit indices			
AIC	19,292.50		
BIC	19,317.40		

Notes: $N = 2{,}737$ days nested within 167 participants.
$^{***}p < .001$; $^{**}p < .01$.

The measurement of curiosity is an active field of research. We focused on curiosity as the propensity to seek out novel, complex, and challenging interactions with the world. Curiosity is multifaceted and additional aspects of curiosity (e.g., Kashdan et al., 2018), including those that conceive of curiosity as a feeling of deprivation that motivates the seeking of information to reduce uncertainty thereby eliminating undesirable states of ignorance (Litman, 2008), were not captured in the present study. Further, the everyday behaviors through which curiosity is theorized to lead to the accruement of knowledge and social resources remain to be characterized. Emerging perspectives conceive of curiosity as a knowledge network building practice in which concepts and the connections between them are added and taken away during the intrinsic information-seeking that characterizes curiosity (Bassett, Lydon-Staley, Zhou, et al., 2019; Zurn & Bassett, 2018). This knowledge network building perspective calls for a greater consideration of everyday curiosity behaviors and presents new tools from network science to formally study the manner in which curiosity drives knowledge network growth. Work from this perspective will represent an important next step to probe the behaviors that accompany micro-time fluctuations in curiosity highlighted by the present work and that are the building blocks of the shoring up of resources that promote well-being.

6 | CONCLUSIONS

In summary, the present study extends previous examinations of the association among curiosity and well-being by demonstrating that the extent to which one consistently reports feeling curious during the course of daily life is associated with well-being. The findings emphasize the importance of considering dynamics in curiosity and, by observing within-person associations among curiosity, depressed mood, happiness, and physical activity, begin the task of identifying potential sources of augmentation and blunting of curiosity in daily life that may be targeted to realize consistent curiosity.

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CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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