Exploring Need Dynamics Within and Across Days in Everyday Life: A Three-Level Analysis

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Highlights

- Investigated dynamic within-person effects of need fulfillment and motivation
- Effects involving competence unfolded within days
- Effects involving relatedness unfolded across days
- No dynamic effects for autonomy were observed

Abstract

People experience frustration of their basic psychological needs (autonomy, competence, relatedness) in daily life, but does this frustration trigger motivation to restore this need and, in turn, to attain need satisfaction? The present study explored the temporal dynamics of need dissatisfaction, motivation, and satisfaction in an ecological momentary assessment (*N*=58; ten daily assessments of need satisfaction, dissatisfaction and motivation for five days). While need dissatisfaction did not predict need motivation overall, need motivation predicted need satisfaction within a day for competence, and across days for relatedness. Potential explanations for this pattern of results are discussed. Findings emphasize the importance of specifying the time frame over which dynamic effects evolve and acknowledging differences between the needs.

Keywords: psychological needs; intensive longitudinal design; within-person; multi-level modeling; ambulatory assessment; self-determination theory

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1. Introduction

Fulfillment of a basic psychological need such as the need to belong (Baumeister & Leary, 1995) or the needs for autonomy, competence, and relatedness (Deci & Ryan, 2000), has been hypothesized to be associated with higher well-being. While there is ample evidence for this assertion, comparatively less is known about the processes that lead to fulfillment versus thwarting of a basic psychological need. In terms of Sheldon's (2011) two-process model (TPM) this might be due to a strong emphasis on the *needs-as-requirements* perspective on psychological needs in prior empirical research. According to this perspective, psychological needs are fundamental nutriments necessary to experience psychological growth, integrity and well-being (Deci & Ryan, 2000). Need fulfillment, thus, constitutes the most fundamental predictor for psychological health.

However, need fulfillment does not occur out of the blue: Humans are not merely passive recipients of external events, but they are active agents shaping their environment to fit their personal preferences (Diener, Larsen, & Emmons, 1984) and current situational demands (Carver & Scheier, 1998). If psychological needs are as fundamentally necessary for psychological health as food and water are for physical survival (Deci & Ryan, 2000), this implies that the frustration of a basic psychological need should prompt individuals to seek to attain experiences that help to fulfill their thwarted need. This *needs-as-motives* perspective (Sheldon, 2011) has so far mainly focused on rather stable inter-individual differences in motives (McClelland, 1985) or situational effects in structured experimental settings. However, research on naturally occurring need dynamics in everyday life is scarce and the temporal dynamics of psychological needs and the motivation to fulfill these needs are not precisely known.

The aim of the present study is to extend the needs-as-motives perspective into people's everyday lives. Specifically, we investigated whether frustration of a basic psychological need would prompt restorative attempts, operationalized as increased motivation to pursue this need, and whether these attempts, in turn, would increase need satisfaction at a later point in time. The next sections will be organized as following: First, we will introduce Self-Determination Theory (Deci & Ryan, 2000) and the TPM of need fulfillment. In this section we will also summarize prior research investigating the association between need fulfillment and need motivation. Next, we will emphasize the importance of taking a within-person perspective with regard to examining the association between need fulfillment and need motivation. We will then report results from a study investigating these associations in study participants' daily lives. To that end, we employed an ecological momentary assessment (EMA; Shiffman et al., 2008; often referred to as experience sampling, Hektner et al., 2007, or ambulatory assessment, Trull & Ebner-Priemer, 2009) investigating need fulfillment and need motivation multiple times a day across five days in participants' everyday lives. The specific data structure allowed us to examine more fast changing within-person dynamics (occurring from hour to hour) together with more slowly changing dynamics (day-to-day effects) and inter-individual differences.

1.1. Need Satisfaction, Need Dissatisfaction, and Their Different Relation to Need Motivation

Our work is based on the conceptual framework of the TPM (Sheldon, 2011) with a focus on the three basic psychological needs for autonomy, competence, and relatedness, as postulated by Self Determination Theory (SDT; Deci & Ryan, 2000). SDT's proposal that fulfillment of these three basic psychological needs is fundamental for human well-being has spawned a substantial amount of research. For example, need fulfillment has been associated with higher well-being on the between-person level (Demir & Özdemir, 2010) and the within-person level (Reis, Sheldon, Gable, Roscoe, & Ryan, 2000). Experimental studies support the

postulated causal effect of need fulfillment on well-being (Sheldon & Filak, 2008). However, in almost all of these studies, fulfillment of each need has been considered a uni-dimensional construct. For example, Gagne's (2003) Basic Psychological Needs Scale assesses the fulfillment of the three needs using both positively worded items assessing need satisfaction (e.g., "Most days I feel a sense of accomplishment from what I do") and (reverse coded) negatively worded items assessing need dissatisfaction (e.g., "Often, I do not feel very competent"). However, recent psychometric work has challenged such a uni-dimensional conceptualization of need fulfillment, strongly suggesting that need satisfaction and need dissatisfaction are more than psychometric opposites (e.g., Chen et al., 2015; Cordeiro, Paixão, Lens, Lacante, & Sheldon, 2016; Neubauer & Voss, 2016a, 2016b; Sheldon & Hilpert, 2012; Tóth-Király, Morin, Bőthe, Orosz, & Rigó, 2017).

The TPM offers a theoretical explanation for this dissociation. This model attempts to unify the needs-as-requirements perspective (which is inherent to SDT) with the needs-as-motives perspective (a viewpoint taken for example by motive disposition theory; McClelland, 1985). One of the core propositions of the TPM is that these two perspectives are intertwined but focus on different time points of an action sequence. According to this model, instances of need dissatisfaction trigger behavioral motives that aim at reducing the perceived lack of domain specific need fulfillment. The action sequence is hypothesized to take the form of a test-operate-test-exit (TOTE) sequence (see Miller, Galanter, & Pribram, 1960). For example, once an individual recognizes that her basic need for relatedness is dissatisfied (test), she is hypothesized to take means to increase her relatedness (operate). She monitors the success of this restoration process (test) until her need for relatedness is satisfied again at which point she terminates the restoration process (exit). This model can provide an explanation for the psychometric separation of need fulfillment into need satisfaction and need dissatisfaction: These two components of need fulfillment should be separated since they exert their effects at different time points. While need dissatisfaction should motivate

individuals to seek out experiences aiming at fulfilling the need, need satisfaction is hypothesized to be the consequence of successful need attainment.

Previous research has yielded results consistent with the prediction that need dissatisfaction predicts higher motivation to fulfill this need. For example, in a cross-sectional study, Sheldon and Gunz (2009) reported data showing that negatively worded items of need fulfillment (indicating need dissatisfaction, e.g. "I struggled doing something I should be good at.") predicted motivation to pursue a need (e.g., "I would like to become very good at some activity that is important to me, and feel less inept and incompetent"), but positively worded items (indicating need satisfaction, e.g. "I was successfully completing difficult tasks and projects") did not. Experimental studies inducing need frustration have reported similar results. For example, experimentally frustrating individuals' need to belong has been shown to result in effects on both explicit motivation for social affiliations, and implicit tuning towards sings for future inclusion (DeWall, Maner, & Rouby, 2009; Knausenberger, Hellmann, & Echterhoff, 2015; Maner, DeWall, Baumeister, & Schaller, 2007). Radel, Pelletier, Sarrazin, and Milyavskaya (2011) showed that frustrating their study participants' need for autonomy (by subjecting them to a controlling context) led to higher accessibility of autonomy related words (faster response times in a lexical decision task for autonomy-related words). Additionally, autonomy deprived participants in this study also relied less on the ostensible ratings of other individuals in their judgements of paintings. These results have been interpreted as an implicit attempt to restore one's dissatisfied need for autonomy.

Further, in a longitudinal study, Sheldon, Abad, and Hinsch (2011) showed that relatedness satisfaction decreased over 48 hours among study participants who had been instructed to refrain from any activity on Facebook. The authors took this finding as support for their hypothesis that Facebook use provides a means for relatedness satisfaction. Of note, average relatedness dissatisfaction did not change during this time window. Two days after the cessation period, participants were asked about their Facebook use in the previous two

days. Those participants who showed the strongest increase in relatedness dissatisfaction over the cessation period reported higher Facebook use after cessation. This finding is in line with the assumption of (inter-individual differences in) relatedness dissatisfaction driving (inter-individual differences in) attempts to restore the thwarted need. Hence, previous research supports the assumption that need satisfaction and need dissatisfaction are more than psychometric opposites and that they are differentially related to the motivation to pursue a basic psychological need.

Additionally, according to the TOTE sequence proposed in the TPM, need motivation is expected to prospectively predict need satisfaction. There is some evidence supporting this hypothesis. Early research on the association between achievement motivation and performance reported positive associations between these two constructs: Participants with higher achievement motivation had better college grades (Weiss, Wertheimer, & Groesbeck, 1959) and solved more word puzzles in an experimental setting (Lowell, 1952). The importance of achievement motivation for school achievement has been demonstrated in several studies (e.g., Steinmayr & Spinath, 2009). Further, positive effects of need motivation on need satisfaction have not only been found for the competence domain: In a study by Sheldon and Schüler (2011) individuals with higher (implicit and explicit) motives had higher levels of fulfillment of the respective need, as compared to their lower motivated counterparts.

Taken together, prior research reported results consistent with the assumptions that (a) need dissatisfaction and need satisfaction are more than psychometric opposites and that they can better be understood as correlated, but distinct constructs; (b) dissatisfaction of a basic psychological need increases the motivation to pursue this need; and (c) higher need motivation increases subsequent need satisfaction.

1.2. The Importance of Distinguishing Within- and Between-Person Analyses

Although these previous findings are intriguing, these studies are highly dominated by a between-person perspective on need fulfillment. For example, despite its longitudinal nature, the study by Sheldon et al. (2011) still focused on inter-individual differences. Specifically, it was inter-individual differences in (change of) need dissatisfaction that predicted need motivation (Facebook use after the cessation period). A true dynamic perspective on need fulfilment requires a within-person perspective with regard to data collection and data analysis. From such a dynamic perspective, the core question becomes whether—within an individual—times of higher need dissatisfaction predict need motivation, which in turn predicts higher need satisfaction later in time. Importantly, questions regarding within-person associations cannot be answered by investigating between-person differences. In his seminal work, Peter Molenaar (2004) showed that between-person relations are equivalent to within-person relations only if the ergodicity assumption is met. This assumption implies that the process under investigation is stationary (meaning that means, (co-)variances, and other characteristics of the process do not change over time) and that the same process accounts for each individual in the population. This assumption will most likely not hold for psychological constructs (Molenaar, 2004) necessitating that within-person processes be investigated by obtaining data that allow for modeling within-person relations among variables. Hence, intensive longitudinal designs are required to address questions about within-person dynamics (Hamaker, 2012).

Recent research has targeted the issues of measurement on the within- and between-person level empirically. For example, in a study by Brose, Voelkle, Lövdén, Lindenberger, and Schmiedek (2015) the well-established two factor structure of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) held at the between-person level (i.e., between-person differences in affect could be described by the two uncorrelated factors positive affect and negative affect), but the degree of convergence of the within-person structure of affect to this between-person structure differed between individuals. Hence,

measurement models (and relations between variables) on the between-person level and the within-person level can diverge, emphasizing the importance of investigating within-person associations when the conceptual interest lies in within-person processes.

With regard to the dynamics of need fulfillment there are two recent studies which investigated the within-person structure of and associations between need satisfaction and need dissatisfaction. Neubauer and Voss (2016a) report results from a multilevel confirmatory factor analysis (MLCFA) on daily diary data, investigating the measurement models of fulfillment of the three basic psychological needs for autonomy, competence, and relatedness. Their results showed that satisfaction and dissatisfaction of these three needs should be separated on both the between-person and within-person level. Hence, the previously reported dissociation of these two need fulfillment dimensions on the between-person level (e.g., Neubauer & Voss, 2016b) holds on the within-person level as well. However, no information on need motivation was obtained and consequently no conclusion on the dynamics of need satisfaction, need dissatisfaction and need motivation can be inferred from this study.

Motivational variables were included in a study by Bidee, Vantilborgh, Pepermans, Griep, and Hofmans (2016). In this study, daily need satisfaction and dissatisfaction were assessed for eight days in a sample of participants volunteering for social care organizations. Additionally, controlled motivation and autonomous motivation for volunteering was assessed at the beginning and the end of the study period. Results from a MLCFA showed that global need satisfaction (i.e. aggregated across the three needs) was highly correlated (r = -.83) with but separable from global need dissatisfaction on the within-person level. The authors expected that changes in need dissatisfaction (satisfaction) would be associated with changes in controlled (autonomous) motivation – an expectation that was not confirmed. Although this study targeted the association of all three constructs of interest to the present research (satisfaction, dissatisfaction, motivation), there are several important differences to our approach: First, Bidee et al. (2016) did not address the within-person dynamics of these

variables. Similarly to the study by Sheldon et al. (2011), they investigated whether between-person differences in change of (dis)satisfaction predicted between-person differences in change of motivation; this does not address the question whether these effects hold on the within-person level. Second, the measures of (dis)satisfaction were aggregated across all three needs, distorting potential differences in the dynamics between the needs for autonomy, competence, and relatedness. Third, the motivation construct assessed by Bidee et al. (2016) refers to the motivation to engage in a specific activity (volunteer work) and it does not address the motivation to specifically pursue the dissatisfied need. Hence, the work by Bidee et al. (2016) did not target the present study's prediction derived from the TPM (Sheldon, 2011).

In summary, while some prior research has investigated the association between need satisfaction, need dissatisfaction and need motivation on the between-person level, no study has thus far targeted these associations from a truly dynamic, within-person perspective.

1.3. The Present Study

In the present study, we used an EMA design, asking study participants up to ten times a day over the course of five consecutive days to report their recent need satisfaction and need dissatisfaction, as well as their current need motivation. With this study, we sought to explore the temporal dynamics of need dissatisfaction, need motivation, and need satisfaction within days and across days in people's everyday lives. Based on predictions derived from the two-process model (Sheldon, 2011) as well as prior experimental (e.g., Knausenberger et al., 2015) and longitudinal research (e.g., Sheldon et al., 2011) we expected that need dissatisfaction should predict need motivation (Hypothesis 1). Need motivation, in turn, was expected to lead to higher need satisfaction at a later point in time (Hypothesis 2). This hypothesis is again based on the TPM and prior research showing a positive link between motivation and need satisfaction (e.g., Sheldon & Schüler, 2011). With this study, we go beyond previous research that has investigated these questions from a between-person

perspective (e.g., Sheldon & Gunz, 2009) or that has not incorporated need motivation in the investigation of within-person need fulfillment associations (Neubauer & Voss, 2016a).

In addition to allowing for a true within-person perspective, the EMA design further opened up the possibility to assess need dynamics on different time scales. It could, for example, be possible that need dissatisfaction has an immediate impact on need motivation, while need motivation might take a longer time to unveil its effect on need satisfaction. In other words: Individuals might be motivated to get in contact with other people who are important to them when they just had a negative social interaction 60 minutes ago. However, this increased motivation might not necessarily result in higher need satisfaction 60 minutes later (e.g., if no important people are currently present), but it might actually take several hours before this increased motivation results in positive experiences. Alternatively, increased motivation today might not exert positive effects on need satisfaction until the next day (see Figure 1 for a schematic representation of the effects on different time scales). Neither previous research nor the TPM allow for making specific predictions about the time scale on which these effects occur. In the present study, we therefore investigated two different time scales: within a day and across days. Since both prior research on this issue and theoretical elaborations are rather silent regarding the time scale on which these effects occur, we investigated both slow dynamics (operating from day to day) and faster dynamics (operating on an hour-to-hour level). Hence, the analyses on the different levels should be regarded as exploratory. We investigated the dynamics for all three needs specified by SDT (autonomy, competence and relatedness). We had no a-priori expectations that the dynamics of these three needs should differ; hence, hypotheses 1 and 2 relate to all three needs.

2. Method

2.1.Participants

Sixty-one participants were recruited for this study.[1] They were recruited from a participant pool at a large German university which primarily consists of students. Since the questionnaires were administered on participants' own smartphones, possession of a smartphone with Android operating system was an inclusion criterion for study participation. Participants were informed in writing that participation was voluntary and that they could terminate the study at any point; all participants provided written informed consent prior to participation in the study. One participant dropped out before the start of the EMA phase of the study. Due to technical problems, two participants provided less than ten assessments and were discarded from further analyses, resulting in a final sample of $N = 58$ ($M_{age} = 22.6$ years, $SD_{age} = 4.5$, 77.6% female).

2.2.Procedure

The study consisted of two parts. In the first part, participants were invited into the laboratory and asked to fill in a package of baseline questionnaires. Next, their own smartphone was linked with the questionnaires for the EMA phase. We used the experience sampling software movisensXS (movisens GmbH, 2016) in the present study. The EMA phase started the following day and ran for five consecutive days. During this period, ten questionnaires were triggered every day between 9:30 a.m. and 9:30 p.m. during weekdays, and between 11 a.m. and 11 p.m. during weekends, respectively, at semi-random time points (prompts were at least 30 minutes apart). After the first prompt of a questionnaire, participants had 15 minutes to fill in the questionnaire; they were reminded five and ten minutes after the initial prompt if they had not filled in the questionnaire yet. On average, participants responded to 38.7 prompts ($SD = 7.7$; $Mdn = 40$) corresponding to an average compliance rate of 77.4% ($Mdn = 80\%$) and yielding a total of 2,245 observations. The average time between

[1] Sample size for this study was not based on formal power analyses since no solid information on the parameters relevant to determine required sample size could be inferred from prior research. Given the intensive longitudinal design of our study, the total number of observations (participants x days x prompts per day) is more relevant for the statistical power than the number of participants alone (Bolger, Stadler, and Laurenceau, 2012). We aimed to attain at least 2,000 data points in total. With a conservatively estimated average compliance of 70%, 60 participants would have been sufficient to obtain this goal (60 x 5 x 10 x .70 = 2,100).

two adjacent measurements (excluding overnight) was 84.6 minutes (*SD* = 46.7). After the five days of assessment, participants returned to the laboratory and were compensated for their participation, receiving either partial course credit or 20€ plus 5€ bonus if they had responded to at least 90% of all prompts.

2.3.Measures

At each prompt, *satisfaction* and *dissatisfaction of the three needs* (autonomy, competence, and relatedness) were assessed with one item each. Specifically, the wording of the items was: "Since the last measurement, I felt a sense of intimacy with the people I spent time with." (relatedness satisfaction), "…, I was free to do things my own way." (autonomy satisfaction), "…, I did well even at the hard things." (competence satisfaction), "…, I felt unappreciated by someone who is important to me" (relatedness dissatisfaction), "…, there were people telling me what to do." (autonomy dissatisfaction), and "…, I was unable to do well at something." (competence dissatisfaction). The items were chosen from the Balanced Measure of Psychological Needs Scale (Sheldon & Hilpert, 2012). In a previous daily diary study, the postulated six-dimensional structure was confirmed for this questionnaire on the within-person level (Neubauer & Voss, 2016a).

Current *need motivation* was assessed with one item per need. These items were also based on items of the BMPN: "At the present moment, I would like to be in contact with people who care for me, and whom I care for." (relatedness motivation), "…I would like to really do what interests me." (autonomy motivation), "…I would like to take on and master hard challenges." (competence motivation). All items were assessed on a seven-point scale ranging from 1 ("completely disagree") to 7 ("completely agree").

2.4.Data Analysis

Data were analyzed using multilevel modeling (MLM). Specifically, with repeated measures taken for several days in several individuals, the data structure can be understood as a three-level structure with measurements (Level 1) nested within days (Level 2), nested

within individuals (Level 3). In the first step, we set up empty models for all nine variables of interest (satisfaction of, dissatisfaction of and motivation for three needs). In these models, only an intercept was included as predictor; random variances of this intercept on the day level and on the person level were estimated. This allowed for a decomposition of the variances into between-person variances, day-to-day-variances, and within-day variances. Next, we set up multi-level models to predict the two dependent variables of interest (need satisfaction and need motivation).

To investigate hypothesis 1, need motivation of person *j* on day *d* and occasion *i* (mot_{idj}) was predicted by current need satisfaction (sat_{idj}) and current dissatisfaction (dis_{idj}), that is, by the variable inquiring how much need satisfaction / dissatisfaction the participant had experienced since the previous assessment. Furthermore, this person's motivation at the previous assessment ($mot_{(i-1)dj}$) was included as predictor as well:

Level 1:

$$mot_{idj} = \beta_{0dj} + \beta_1(sat_{idj}) + \beta_2(dis_{idj}) + \beta_3(mot_{(i-1)dj}) + \varepsilon_{idj} \quad (1)$$

On level 2, person *j*'s average motivation on day *d* was predicted by this day's average satisfaction ($day.sat_{dj}$), this day's average need dissatisfaction ($day.dis_{dj}$), as well as the average need satisfaction, need dissatisfaction, and need motivation of the previous day ($day.sat_{(d-1)j}$; $day.dis_{(d-1)j}$; $day.mot_{(d-1)j}$)

Level 2:

$$\beta_{0dj} = \gamma_{0j} + \gamma_1(day.sat_{dj}) + \gamma_2(day.dis_{dj}) \quad (2)$$
$$+\gamma_4(day.sat_{(d-1)j}) + \gamma_5(day.dis_{(d-1)j}) + \gamma_6(day.mot_{(d-1)j}) + \zeta_{dj}$$

Finally, on the person level (Level 3), average need motivation was modeled as a function of person *j*'s average need satisfaction ($person.sat_j$) and dissatisfaction ($person.dis_j$):

Level 3:

$$\gamma_{0j} = \pi_0 + \pi_1(person.sat_j) + \pi_2(person.dis_j) + \upsilon_j \quad (3)$$

Combining the three level specific equations yields the final equation for need motivation:

$$
\begin{aligned}
mot_{idj} = \quad & \pi_0 + \zeta_{dj} + \upsilon_j \\
& + \pi_1(person.sat_j) + \pi_2(person.dis_j) \\
& + \gamma_1(day.sat_{dj}) + \gamma_2(day.dis_{dj}) \\
& + \gamma_4(day.sat_{(d-1)j}) + \gamma_5(day.dis_{(d-1)j}) + \gamma_6(day.mot_{(d-1)j}) \\
& + \beta_1(sat_{idj}) + \beta_2(dis_{idj}) + \beta_4(mot_{(i-1)dj}) + \varepsilon_{idj}
\end{aligned} \tag{4}
$$

Previous research has shown that measures of need satisfaction and dissatisfaction often overlap and are not completely orthogonal (e.g., Neubauer & Voss, 2016b; Tóth-Király et al., 2017). Therefore, to investigate the unique effect of need dissatisfaction on need motivation, we controlled for need satisfaction in this model.

The model for predicting current need satisfaction was similar:

$$
\begin{aligned}
sat_{idj} = \quad & \pi_0 + \zeta_{dj} + \upsilon_j \\
& + \pi_2(person.dis_j) + \pi_3(person.mot_j) \\
& + \gamma_2(day.dis_{dj}) + \gamma_3(day.mot_{dj}) \\
& + \gamma_4(day.sat_{(d-1)j}) + \gamma_5(day.dis_{(d-1)j}) + \gamma_6(day.mot_{(d-1)j}) \\
& + \beta_2(dis_{idj}) + \beta_3(sat_{(i-1)dj}) + \beta_4(mot_{(i-1)dj}) + \varepsilon_{idj}
\end{aligned} \tag{5}
$$

In both models, the dependent variable was predicted by the other two need components (either satisfaction and dissatisfaction or dissatisfaction and motivation) as well as the lagged effects of all three need components on the between-day level. On the within-day level, we selectively included only those predictors that were conceptually meaningful. For example, predicting current need satisfaction (i.e., the degree to which a need had been satisfied since the last assessment) by current need motivation is not meaningful, since motivation was assessed with regard the present state of the individual (“At the present

moment, I would like to…"), whereas need satisfaction was assessed with regard to a previous time point ("Since the last measurement…").

Level-1 predictors (associated with the β's in Equations (4) and (5)) were centered on the person specific day mean, Level-2 predictors (see γ's) were centered on the person mean, and Level-3 predictors (see π's) were centered on the grand mean. This centering strategy results in pure within-level estimates of all effects, that is, an estimation of within day, across day, and across person effects of the variables of interest, respectively (see Brincks et al., 2017, for a recent discussion of different centering strategies in three-level models). Lagged variables for the first assessment of each day were set to missing (i.e., the first assessment each day was not predicted by the last assessment of the previous day). All analyses were performed in R version 3.3.3; multi-level models were estimated using the nlme package (Pinheiro, Bates, DebRoy, Sarkar, & R. Development Core Team, 2017). Data can be retrieved from https://osf.io/6krj7/.

3. Results

Table 1 depicts the variance decomposition of the nine study variables. Satisfaction and dissatisfaction of the three needs exhibited most variation on the within-day level (between 54.4% and 66.2% of the total variance). For competence motivation and relatedness motivation, variance proportions across persons (Level 3) and within days (Level 1) were approximately equal; for autonomy motivation, there was more variance on the within-day level than on the between-person level. Variance across days was smaller than the variances across the other two levels for all nine variables (ranging from 9.7% to 17.3% of the total variance). Although smaller, this variance was statistically meaningful in that removing the random intercept variance across days deteriorated model fit for all nine variables, $\chi^2(1) > 76.19$, $p < .001$ for all.

Descriptive statistics are depicted in Table 2. Within-person correlations were obtained via three level models in Mplus (version 8.1). On the between-person level, for all

three needs, need satisfaction correlated negatively with need dissatisfaction, $r < -.27$, and positively with need motivation, $r > .31$. Need dissatisfaction was uncorrelated with need motivation, $|r| < .08$, $p > .545$ for all. Correlations on the within-person levels were more heterogeneous and dependent on the level (within vs. across days) and need. For example, need satisfaction was negatively correlated with need dissatisfaction both within and across days for autonomy, but only across days for relatedness.

3.1.Hypothesis 1: Predicting Momentary Need Motivation

In the first set of models, we predicted current need motivation from the predictors introduced in the section *Data Analysis*. Results (see Table 3, left panel) on the between-person predictors echoed the findings from the between-person correlations: Only need satisfaction, but not need dissatisfaction predicted average need motivation on the person-level. Although the effect of need dissatisfaction was descriptively in the expected (positive) direction, the effects failed to reach significance for competence, $p = .173$, relatedness, $p = .531$, and autonomy, $p = .054$.

For *autonomy* motivation, there was no significant effect of any predictor on the between-day or within-day level, $p > .199$ for all. *Competence* motivation was predicted by competence satisfaction on all three levels: Participants who experienced more competence satisfaction on average also reported higher competence motivation on average, $b = .97$, $p < .001$. On days when participants reported higher competence satisfaction (compared to days with lower competence satisfaction), participants also reported higher competence motivation, $b = .35$, $p < .001$. And finally, on occasions when participants reported higher competence satisfaction since the last measurement occasion, they also reported higher competence motivation, $b = .18$, $p < .001$. Contrary to our expectations, there was no effect of competence dissatisfaction on any level, $|b| < .21$, $p > .173$ for all.

Relatedness motivation was unrelated to all predictors on the within-day level, $|b| < .05$, $p > .113$ for all. On the between-day level, both today's satisfaction and dissatisfaction

were positively associated with relatedness motivation, $b = .15$, $p = .005$, and $b = .23$, $p = .002$, respectively. That is, days with higher relatedness satisfaction or relatedness dissatisfaction were also days with higher relatedness motivation. In addition, there was a significant effect of yesterday's relatedness dissatisfaction, $b = -.18$, $p = .008$, indicating that relatedness motivation was reduced after a day with high relatedness dissatisfaction.

In conclusion, Hypothesis 1 that need dissatisfaction leads to higher need motivation received no support: motivation was unrelated to dissatisfaction for both autonomy and competence. For relatedness, there was a positive association of dissatisfaction and motivation on the day level. However, lagged effects suggested that high day-level dissatisfaction predicted reduced (instead of increased) motivation on the next day.

3.2.Hypothesis 2: Predicting Momentary Need Satisfaction

Results for the models with momentary need satisfaction as dependent variable are depicted in Table 3 (right panel). On the between-person level, average satisfaction was positively associated with motivation, and negatively associated with need dissatisfaction for autonomy and competence, whereas the association of relatedness dissatisfaction and relatedness satisfaction failed to reach significance, $p = .079$. Within individuals, *autonomy* satisfaction was only related to autonomy dissatisfaction; this association held both within days, $b = -.31$, $p < .001$, and across days, $b = -.61$, $p < .001$. There was no within-person association of autonomy motivation and autonomy satisfaction, on the between-day level, $b < .04$, $p > .621$, or the within-day level, $b = -.02$, $p = .543$. *Competence* satisfaction was higher on days with higher competence motivation, $b = .34$, $p < .001$. Within days, higher motivation at the previous assessment was associated with higher satisfaction at the current assessment, $b = .07$, $p = .023$. Finally, *relatedness* satisfaction on the day level was associated with relatedness dissatisfaction, $b = -.45$, $p < .001$, and relatedness motivation, $b = .33$, $p = .008$. Of note, there was also a positive lagged effect of yesterday's motivation on today's satisfaction,

b = .24, p = .041. Within days, relatedness motivation was unrelated to relatedness satisfaction, b = .01, p = .763.

To sum up, there were no within-person effects of autonomy motivation on autonomy satisfaction. Competence satisfaction was higher (a) on days with higher competence motivation, and (b) at occasions following higher competence motivation. Relatedness satisfaction was higher (a) on days with higher relatedness motivation, and (b) on days after higher relatedness motivation.[2]

3.3.Exploratory Analyses: Lag-2

Finally, we explored whether effects of need dissatisfaction on motivation or effects of need motivation on need satisfaction *within* a day are more pronounced with further lags. Specifically, for the first set of models (predicting current need motivation), we entered need dissatisfaction at lag 1 (need dissatisfaction before the previous assessment) and at lag 2 (need dissatisfaction before two assessments back). For autonomy motivation and relatedness motivation, none of the lagged effects was statistically significant, $p > .237$ for all. Lag-2 competence dissatisfaction was associated with higher competence motivation, b = .06, p = .045. That is, competence dissatisfaction was associated with higher competence motivation on occasions approximately three to four hours later. For the second set of models, we added lag-2 need motivation to predict current need satisfaction. None of the lag-2 motivation effects were significant, $p > .211$ for all.

4. Discussion

According to theories of basic psychological needs (Baumeister & Leary, 1995; Deci & Ryan, 2000) these needs are essential for psychological adjustment for virtually all humans. A frustration of a basic psychological need can therefore be expected to set in motion attempts to restore the thwarted need – and successful need restoration should, in turn,

[2] Need satisfaction and dissatisfaction were assessed by asking whether events had occurred since the last assessment. Because for the morning assessments, these lags were longer than for the remaining assessments we investigated whether these longer periods might have affected our results. Excluding all morning assessments before running the analyses did, however, not change the pattern of results.

predict future need satisfaction (Sheldon, 2011). Previous research has shown some evidence for these assertions, but so far there was no study investigating these dynamic effects within individuals in their everyday lives. In the present study, we investigated the dynamic interplay of need dissatisfaction, need motivation, and need satisfaction of the three needs for autonomy, competence, and relatedness in an ecological momentary assessment and we targeted both effects unfolding on a shorter time scale (within days) and a longer time scale (across days).

4.1. Does Need Dissatisfaction Predict Higher Need Motivation?

Lacking the nutrients necessary for positive psychological functioning should motivate individuals to attain these needs (see dashed black arrows in Figure 1). The present study tested this hypothesis for the three needs for autonomy, competence, and relatedness.

Within days, we found no evidence for an effect of recent need dissatisfaction on current need motivation for any of the three needs. The lack of effects for need dissatisfaction on need motivation stands in contrast to expectations based on the TPM (Sheldon, 2011). Notably, however, our primary analyses focused on the immediate effects of dissatisfaction on motivation. Need dissatisfaction might require more than the one to two hours investigated in the present study to exert its positive effects on need motivation. In fact, results from our exploratory analyses suggest that for one of the investigated needs—competence—this might be the case: Competence dissatisfaction that had occurred before two assessments ago was positively associated with current competence motivation. That is, results suggest that competence dissatisfaction has no immediate effect on competence motivation, but it did predict motivation approximately three to four hours later. It is important to note, however, that these results are based on exploratory analyses and similar effects were not observed for the other two needs, relatedness and autonomy. Hence, these results need to be interpreted cautiously.

The lack of an effect of relatedness dissatisfaction on subsequent motivation stands in contrast to prior experimental research which suggests almost immediate effects of belongingness frustration on motivational variables (Gardner, Pickett, & Brewer, 2000; Gardner, Pickett, Jefferis, & Knowles, 2005; Maner et al., 2007). Potentially, subtle differences between the need to belong and the need for relatedness might account for these diverging findings. In light of the belongingness orientation model (Lavigne, Vallerand, & Crevier-Braud, 2011), belongingness motivation can be of two distinct qualities: growth oriented or deficit-reduction oriented. The former orientation can be understood as a genuine interest towards other people, which provides the basis for positive interpersonal development (Lavigne et al., 2011). This conceptualization of a growth oriented approach to the regulation of social relationships is in line with the need for relatedness as postulated by SDT (Deci & Ryan, 2000). For this reason, the way we assessed relatedness motivation ("At the present moment, I would like to be in contact with people who care for me, and whom I care for.") is to be understood as a growth oriented motivation. In contrast, a deficit-reduction orientation can be described as the attempt to "fill a social void" (Lavigne et al., 2011, p. 1186), that is, establishing non-negative interactions with other people – a core feature of the need to belong as defined by Baumeister and Leary (1995). Need motivation operationalized as increased motivation to work together with other people (Maner et al., 2007) or to join a new online community (Knausenberger et al., 2015) can rather be considered deficit-reduction oriented motivation. Future studies should therefore consider comparing the effect of relatedness frustration on growth oriented motivation (as assessed in the present study) to its effect on deficit-reduction oriented motivation.

Regarding the analyses of slower moving dynamics, yesterday's need dissatisfaction was unrelated to today's need motivation for autonomy and competence. For relatedness, however, day-to-day fluctuations in relatedness dissatisfaction were associated with variation in relatedness motivation. Specifically, days with higher overall levels of relatedness

dissatisfaction were also days with higher overall relatedness motivation. Although this finding is consistent with predictions made by the TPM (Sheldon, 2011), the lagged effect was negative, with lower relatedness motivation on days following high relatedness dissatisfaction. A tentative, yet speculative explanation for this finding could be that relatedness dynamics might be better represented as coupled oscillating processes (for an example of an application of these models in psychology see Boker & Laurenceau, 2006), where dissatisfaction leads to an initial reduction in motivation on the next day, but a higher motivation two days later. Of note, results on the day-to-day dynamics are based on only five days, precluding firm conclusions about effects evolving over more than one day. We were therefore not able to examine these longer time spans in more detail. Future studies investigating the dynamics of relatedness might therefore consider using a longer time span (e.g., two or three weeks).

In summary, we found no clear support for the hypothesis that need dissatisfaction predicts higher subsequent need motivation. For autonomy, there were no effects on either the within- or between-day level. For relatedness, days with higher need dissatisfaction were also days with higher need motivation, but there was no evidence for any positive lead-lag associations between these two variables. For competence, exploratory analyses suggest that competence dissatisfaction might predict higher competence motivation 3-4 hours later.

4.2. Does Need Motivation Predict Higher Need Satisfaction?

Across all measurement occasions, participants with higher need motivation were on average also participants with higher need satisfaction. The TPM (Sheldon, 2011) postulates that this association can be explained by a positive effect of need motivation on need satisfaction (see solid red arrows in Figure 1). We tested this hypothesis by examining the effects of current need motivation on subsequent need satisfaction.

Within days, there was no evidence for such an effect pattern for the needs for autonomy and relatedness: Higher motivation to pursue these needs did not bring about higher

satisfaction within the next 1-2 hours. For the need for competence, the expected effect was, however, observed: Higher competence motivation now was associated with higher competence satisfaction at the next measurement occasion. On the between-day level, there were again no effects for autonomy. That is, higher than usual autonomy motivation was not associated with higher autonomy satisfaction on the same day or the next day. For competence, only the same day association was significant: Days with higher competence motivation were also days with higher competence satisfaction. No lagged associations emerged on the between-day level for competence. For relatedness, both today's and yesterday's motivation were positively associated with higher satisfaction today, yielding evidence consistent with study hypothesis 2.

In conclusion, our results yielded mixed support for the hypothesis that need motivation predicts higher subsequent need satisfaction. No such effect for autonomy occurred on either the within-day or between-day level. For competence and relatedness, the postulated effects occurred on different time scales: Whereas competence motivation at the previous assessment predicted competence satisfaction at the current assessment (within days), relatedness motivation predicted relatedness satisfaction at the next day (across days). Hence, motivational benefits of attaining relatedness seem to unfold over a longer time span as compared to the need for competence.

4.3. Implications for Future Research

4.3.1. The Importance of Time Scales

Our results emphasize the importance of the time scales over which postulated effects occur. The insight that effects can occur over different time scales is not a new one and has lead researchers to propose specific designs (e.g., measurement burst designs; Nesselroade, 1991; Sliwinski, 2008) and data analytic techniques (e.g., continuous time modeling; de Haan-Rietdijk, Voelkle, Keijsers, & Hamaker, 2017; Voelkle, Oud, Davidov, & Schmidt, 2012) to accommodate this phenomenon. In the present context of the dynamics of need

fulfillment and need motivation, previous theorizing and empirical research have been vague with respect to this important question. Our results showed that the time frame chosen for the analyses partly determined whether the expected effects were found or not. For example, motivation predicted satisfaction for the need for competence in the next 1-2 hours, but not from day to day, while the reverse was true for the need for relatedness. We are not aware of either theoretical accounts or previous research that has explicitly specified the time course over which need dynamic processes are expected to emerge. In experimental studies (e.g., DeWall et al., 2009; Knausenberger et al., 2015; Radel et al., 2011) the implicit assumption is that the effects of need dissatisfaction on need motivation emerge within a very short time frame (within the experimental session), but there is no theoretical justification for this assumption. The results reported in the present study can be considered an empirical starting point for future research. They suggest that dynamics involving the need for competence develop within a day, whereas the dynamics involving the need for relatedness have longer latencies, occurring on the between-day level.

A preliminary, speculative explanation for this pattern of results could be that the possibility to attain competence is substantially less confined by external environments than the possibility to attain relatedness. Feeling close to and connected with other important people requires that these people are available. In contrast, competence can be attained more directly by engaging with challenging tasks. Hence, differences in the immediate availability of external resources required to fulfill the need might determine the temporal time scale of need related dynamics: When environmental conditions allow for a more or less immediate restoration of the needs (such as in experimental studies in which the possibility to join a new online community is provided right away), need dissatisfaction might trigger need motivation very quickly, whereas when environmental conditions do not allow for restoring the thwarted need in a timely manner (e.g., because no important people are currently present), the effect might be postponed (or, if the environment is chronically unable to provide need fulfilling

means, need dynamics may be distorted altogether; Sheldon, 2011). Hence, the differences in temporal dynamics between the need for competence and the need for relatedness observed in the present study might be a result of more immediate availability of environmental resources that allow for restoring the need for competence vs. the need for relatedness in study participant's daily lives.

Most certainly, the present findings need to be replicated before any definite conclusions can be drawn. Nevertheless, we consider these results as important information that can be used to inform the choice of temporal designs in future studies. Further, with more empirical research accumulating on the temporal dynamics of need fulfillment, these findings can then be integrated into theoretical models explicitly incorporating time as a relevant dimension describing these psychological phenomena.

4.3.2. The Role of Autonomy

One of the central criteria for basic psychological needs is that their dissatisfaction needs to be associated with a motivation to restore this need (Baumeister & Leary, 1995). While the evidence for such an association was only weak for competence (in exploratory analyses) and relatedness (on the between-day level), there was no such association for the need for autonomy.

One explanation for the consistent negative results involving autonomy could be that dissatisfaction of autonomy does not prompt restorative attempts, which would ultimately undermine its status as a basic psychological need according to the criteria by Baumeister and Leary (1995). This explanation would further be in line with previous research that has shown that autonomy has sometimes no predictive validity on well-being indicators after fulfillment of other needs is being controlled for (Neubauer, Schilling, & Wahl, 2017; Neubauer & Voss, 2016a). However, other research does report effects of autonomy above and beyond fulfillment of other needs (e.g., Neubauer & Voss, 2016b; Reis et al., 2000; Vansteenkiste,

Lens, Soenens, & Luyckx, 2006). Hence, revoking the need for autonomy's status as a basic psychological need based only on the present findings would be premature.

A different explanation for the lack of dynamic effects involving autonomy fulfillment in the present study could be located at the level of operationalization: The items capturing motivation for relatedness and competence might be perceived to capture more specific behaviors ("take on and master hard challenges"; "be in contact with people who care for me, and whom I care for") compared to the item measuring autonomy motivation ("like to really do what interests me"). Hence, the associations involving autonomy motivation might have failed to emerge due to its assessment as a less concrete behavioral goal compared to the other two needs. However, on the between-person level, the zero-order correlations (see Table 2) revealed the same pattern for autonomy as compared to the other two needs (positive correlation between satisfaction and motivation, no correlation between dissatisfaction and motivation). If differences in the specificity of assessment of the three needs were the main reason for the null-findings regarding autonomy, we would expect that the pattern of between-person correlations would also differ from the pattern of the other two needs. Since this was not the case in our data, we consider it unlikely that differences in the specificity of the assessment solely explain the diverging results of the need for autonomy.

Based on theoretical grounds and previous research that has mostly yielded evidence in favor of autonomy being a basic psychological need, we consider it more likely that the time frame chosen for the present study (1-4 hours within a day; and from day-to-day) does not adequately capture the latency of the dynamic effects. Additionally, it might not be single incidences of autonomy dissatisfaction but rather accumulative effects that are necessary to trigger autonomy motivation. Short, single bouts of autonomy dissatisfaction (e.g., being told what to do; having to do things against one's will) may not be severe enough to trigger the motivation to engage in different, more autonomy promoting activities. In fact, many individuals have obligations in their daily lives (e.g., work or household) which are not aimed

towards fulfilling their need for autonomy. A mechanism which triggers motivation for competing activities more or less instantaneously in these situations might be maladaptive since this motivation could extract energy from individuals' daily obligations. Rather, such increased motivation could either be "postponed" to more fitting periods (e.g., high autonomy dissatisfaction during the day might predict autonomy motivation in the evening) or not be relevant unless dissatisfaction accumulates over a longer time frame (e.g., accumulated autonomy dissatisfaction throughout the working week might predict autonomy motivation on the weekends). Hence, future research should consider examining cumulative effects of autonomy dissatisfaction on autonomy motivation (for approaches to examine accumulative effects see e.g., Schilling & Diehl, 2014; Smyth et al., 2018)

4.3.3. Refinement of Measures Capturing Need Fulfillment

Given the sparse research on this topic, we aimed at investigating the dynamics of all three needs postulated by SDT. As a consequence, assessment of need satisfaction, dissatisfaction, and motivation was based on single item indicators, in order to keep participant burden as low as possible. Although single item assessments have proven to be valid in some scenarios (Cheung & Lucas, 2014; Elo, Leppanen, & Jahkola, 2003), they certainly come at the expense of low reliability and may not cover the full breadth of the assessed construct. Although we picked indicators that have shown high loadings on their designated within-person factor in a previous study (Neubauer & Voss, 2016a), they arguably cannot capture the whole breadth of the underlying construct.

Scales measuring need satisfaction and dissatisfaction have been developed and validated in previous research (e.g., Chen et al., 2015; Neubauer & Voss, 2016a; Sheldon & Hilpert, 2012), but the applied validation methods were almost exclusively based on self-reports. Hence, future research should consider validating need fulfillment measures with different approaches, for example using proxy-reports or experimental manipulations. Further, in particular the items measuring need dissatisfaction assess the occurrence of rather specific

events (e.g., “there were people telling me what to do”) and it is (often implicitly) assumed that the occurrence of such events leads to need dissatisfaction, regardless of other situational circumstances. However, the same event (e.g., being told what to do) might be perceived as need dissatisfying or not (e.g., a person might be glad that somebody gave her instructions, because she would not have known what to do without these instructions). More important than the actual event might be the appraisal of the event (see Lazarus & Folkman, 1984). Hence, the occurrence of a specific event is not sufficient to evoke need (dis)satisfaction. At the same time, under certain circumstances, concrete events are also not necessary for experiencing need (dis)satisfaction. For example, if an individual expects a call from a friend but this friend does not call, the individual might feel unappreciated by someone who is important to her and might respond with “completely agree” to the respective item (“I felt unappreciated by someone who is important to me”). Therefore, it is not necessary that an actual conversation happens for this individual to have her (relatedness) need dissatisfied. Future studies should consider that the appraisal of an event is arguably more important for its impact on need (dis)satisfaction than its mere occurrence and explicitly consider this in the development and refinement of scales capturing need (dis)satisfaction.

4.3.4. Inter-Individual Differences in Need Dynamics

Inter-individual differences in the postulated need dynamics can be very interesting from a theoretical perspective. According to Dweck (2017), “as individuals experience needs and pursue need-fulfilling goals they develop representations of their experiences that are fundamental to their motivation and that play a major role in the formation of their personality” (p. 689). In this regard, dynamic processes linking need motivation to need fulfillment are important for the formation, stabilization and development of personality traits. For example, individuals who consistently fail to achieve relatedness satisfaction might in the long run give up pursuing this need (see Sheldon, 2011). By this mechanism, learning experiences could give rise to stable personality traits such as introversion (which is

characterized by low sociability). This reasoning can provide the starting point for future research on personality using measurement burst designs (Sliwinski, 2008). Such designs allow for examining whether inter-individual differences in these dynamics longitudinally predict personality development across the lifespan. Above this, they have the potential to meet recent calls for a better integration of structure, process and development of personality (Baumert et al., 2017). However, before inter-individual differences in need dynamics can be thoroughly investigated, a better understanding of the involved processes in required (e.g., across which time span do these effects unfold? How can we best measure need fulfillment and need motivation?). The present study provides a starting point for a research program that can help better understand these dynamics and inter-individual differences therein.

4.4.Limitations

In interpreting our findings, a number of limitations have to be considered. First, the sample was a convenience sample, primarily consisting of students. Sample size on the person level was relatively low, which precluded analyzing potential inter-individual differences in the need dynamics studied here. Larger, more heterogeneous samples are required to test the generalizability of our findings beyond university students and to investigate potential person-level moderators. While SDT generally assumes that effects of need fulfillment are universal across individuals regardless of inter-individual differences in sex, culture or personality, there is some research showing that there may be inter-individual differences in the extent to which need fulfillment is linked to individuals' well-being (Neubauer, Lerche, & Voss, 2018). Moreover, it is further argued in the TPM that chronic dissatisfaction of a basic psychological need disrupts the adaptive dynamics of need dissatisfaction leading to higher need motivation (Sheldon, 2011).

Second, because items capturing need satisfaction and need dissatisfaction capture rather specific events, these constructs needed to be assessed with respect to a certain time frame that has passed ("since the last measurement"). In contrast, need motivation was

assessed as the current state ("at the present moment"). This created an asymmetry with respect to the statistical models employed: Specifically, for the models predicting need satisfaction from need motivation, lagged analyses were employed (motivation assessed at the previous assessment predicting satisfaction at the current assessment), while concurrent models were used for the prediction of need motivation (need dissatisfaction assessed at the current assessment as predictor of need motivation at the current assessment). Furthermore, although findings point towards time windows that might be relevant for the effects of competence need dissatisfaction (3-4 hours) these findings are based on exploratory analyses. To address these two issues, future studies could consider using an event-contingent sampling strategy: Participants might be asked to start a survey each time they experience an event of need frustration. Contingent on this reporting, they can be assessed with high frequency for up to five or six hours to capture the dynamics of need motivation and need satisfaction following need dissatisfaction with a higher temporal resolution. This sampling design would also allow for using lagged analyses for the prediction of both need satisfaction and need motivation (because current need motivation could be predicted from previous need dissatisfaction).

Third, it should be noted that the findings presented here are only representative of the time lags under investigation (between about one to four hours within a day, or from one day to the next). Temporal dynamics of need fulfillment might follow a time course different from the time windows investigated here (e.g., shorter than one hour or longer than one day). No clear predictions on the time-frame across which the postulated effects evolve could be delineated from prior research or the TPM. Since our study is the first to examine this question, our findings can provide a starting point for future research on this issue.

Finally, while need motivation should on average predict need fulfilment (Sheldon, 2011), this is not to be expected in all situations: Although sometimes people may want to feel more autonomous or connected with other people, situational constraints might prevent

them from actually attaining need satisfaction. Situational moderators such as the availability of close others might account for the time scale across which temporal dynamics occur (see section 4.3.1.) and should be investigated in future research as potential moderators of the dissatisfaction – motivation – satisfaction association.

4.5.Conclusions

The present study is the first attempt to investigate within-person dynamics of need fulfillment and need motivation in people's daily lives. Our results showed that motivation to attain competence and relatedness translated into higher need satisfaction: for competence, the effects were faster, operating within a day, whereas relatedness motivation on one day predicted relatedness satisfaction on the next day. Dissatisfaction of the need for competence was associated with higher motivation to pursue competence approximately 3-4 hours later, and days with higher relatedness dissatisfaction were also days with higher relatedness motivation. We found no evidence for need dynamics involving the need for autonomy. Our results stress the importance of considering the dynamics on multiple time scales (within days versus across days).

References

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*, 497–529. https://doi.org/10.1037/0033-2909.117.3.497

Baumert, A., Schmitt, M., Perugini, M., Johnson, W., Blum, G., Borkenau, P., . . . Mõttus, R. (2017). Integrating Personality Structure, Personality Process, and Personality Development. *European Journal of Personality*, *31*, 503–528. https://doi.org/10.1002/per.2115

Bidee, J., Vantilborgh, T., Pepermans, R., Griep, Y., & Hofmans, J. (2016). Temporal dynamics of need satisfaction and need frustration. Two sides of the same coin? *European Journal of Work and Organizational Psychology*, *25*, 900–913. https://doi.org/10.1080/1359432X.2016.1176021

Boker, S. M., & Laurenceau, J.-P. (2006). Dynamical systems modeling: An application to the regulation of intimacy and disclosure in marriage. In T. A. Walls & J. L. Schafer (Eds.), *Models for intensive longitudinal data* (pp. 195–218). Oxford, New York: Oxford University Press.

Bolger, N., Stadler, G., & Laurenceau, J.-P. (2012). Power analysis for intensive longitudinal studies. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (pp. 285–301). New York: Guilford Press.

Brincks, A. M., Enders, C. K., Llabre, M. M., Bulotsky-Shearer, R. J., Prado, G., & Feaster, D. J. (2017). Centering predictor variables in three-level contextual models. *Multivariate Behavioral Research*, *52*, 149–163. https://doi.org/10.1080/00273171.2016.1256753

Brose, A., Voelkle, M. C., Lövdén, M., Lindenberger, U., & Schmiedek, F. (2015). Differences in the between-person and within-person structures of affect are a matter of degree. *European Journal of Personality*, *29*, 55–71. https://doi.org/10.1002/per.1961

Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behavior*. Cambridge: Cambridge Univ. Press.

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Van der Kaap-Deeder, Jolene, . . . Verstuyf, J. (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion*, *39*, 216–236. https://doi.org/10.1007/s11031-014-9450-1

Cordeiro, P., Paixão, P., Lens, W., Lacante, M., & Sheldon, K. (2016). Factor structure and dimensionality of the balanced measure of psychological needs among Portuguese high school students. Relations to well-being and ill-being. *Learning and Individual Differences*, *47*, 51–60. https://doi.org/10.1016/j.lindif.2015.12.010

Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of goal pursuits: Human needs and the Self-Determination of behavior. *Psychological Inquiry*, *11*, 227–268. https://doi.org/10.1207/S15327965PLI1104_01

Demir, M., & Özdemir, M. (2010). Friendship, need satisfaction and happiness. *Journal of Happiness Studies*, *11*, 243–259. https://doi.org/10.1007/s10902-009-9138-5

DeWall, C. N., Maner, J. K., & Rouby, D. A. (2009). Social exclusion and early-stage interpersonal perception: selective attention to signs of acceptance. *Journal of Personality and Social Psychology*, *96*, 729–741. https://doi.org/10.1037/a0014634

Diener, E., Larsen, R. J., & Emmons, R. A. (1984). Person x situation interactions: Choice of situations and congruence response models. *Journal of Personality and Social Psychology*, *47*, 580–592.

Dweck, C. S. (2017). From needs to goals and representations: Foundations for a unified theory of motivation, personality, and development. *Psychological Review*, *124*, 689–719. https://doi.org/10.1037/rev0000082

Gagné, M. (2003). The role of autonomy support and Autonomy orientation in prosocial behavior engagement. *Motivation and Emotion*, *27*, 199–223. https://doi.org/10.1023/A:1025007614869

Gardner, W. L., Pickett, C. L., & Brewer, M. B. (2000). Social exclusion and selective memory: How the need to belong influences memory for social events. *Personality and Social Psychology Bulletin*, *26*, 486–496. https://doi.org/10.1177/0146167200266007

Gardner, W. L., Pickett, C. L., Jefferis, V., & Knowles, M. (2005). On the outside looking in: loneliness and social monitoring. *Personality & Social Psychology Bulletin*, *31*, 1549–1560. https://doi.org/10.1177/0146167205277208

Haan-Rietdijk, S. de, Voelkle, M. C., Keijsers, L., & Hamaker, E. L. (2017). Discrete- vs. continuous-time modeling of unequally spaced experience sampling method data. *Frontiers in Psychology*, *8*, 1849. https://doi.org/10.3389/fpsyg.2017.01849

Hamaker, E. L. (2012). Why researchers should think "within-person". A paradigmatic rationale. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (pp. 43–61). New York: Guilford Press.

Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*. Thousand Oaks, Calif: Sage Publications.

Knausenberger, J., Hellmann, J. H., & Echterhoff, G. (2015). When virtual contact is all you need: Subtle reminders of Facebook preempt social-contact restoration after exclusion. *European Journal of Social Psychology*, *45*, 279–284. https://doi.org/10.1002/ejsp.2035

Lavigne, G. L., Vallerand, R. J., & Crevier-Braud, L. (2011). The fundamental need to belong: on the distinction between growth and deficit-reduction orientations. *Personality & Social Psychology Bulletin*, *37*, 1185–1201. https://doi.org/10.1177/0146167211405995

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. New York: Springer Publishing Company.

Lowell, E. L. (1952). The effect of need for achievement on learning and speed of performance. *The Journal of Psychology*, *33*, 31–40. https://doi.org/10.1080/00223980.1952.9712815

Maner, J. K., DeWall, C. N., Baumeister, R. F., & Schaller, M. (2007). Does social exclusion motivate interpersonal reconnection? Resolving the "porcupine problem". *Journal of Personality and Social Psychology*, *92*, 42–55. https://doi.org/10.1037/0022-3514.92.1.42

McClelland, D. C. (1985). *Human motivation*. Glenview, Ill.: Scott, Foresman.

Miller, G. A., Galanter, E., & Pribram, K. H. (1960). *Plans and the structure of behavior*. New York: Henry Holt and Co.

Molenaar, P. C. M. (2004). A manifesto on psychology as idiographic science: Bringing the person back into scientific psychology, this time forever. *Measurement: Interdisciplinary Research & Perspective*, *2*, 201–218. https://doi.org/10.1207/s15366359mea0204_1

Movisens GmbH. (2016). movisensXS. Karlsruhe.

Nesselroade, J. R. (1991). The warp and woof of the developmental fabric. In R. Downs, L. Liben, & D. S. Palermo (Eds.), *Visions of aesthetics, the environment, and development: The legacy of Joachim F. Wohwill* (pp. 213–240). Hillsdale, NJ: Lawrence Erlbaum Associates.

Neubauer, A. B., Lerche, V., & Voss, A. (2018). Interindividual differences in the intraindividual association of competence and well-being: Combining experimental and intensive longitudinal designs. *Journal of Personality, 86, 698–713.* https://doi.org/10.1111/jopy.12351

Neubauer, A. B., Schilling, O. K., & Wahl, H.-W. (2017). What do we need at the end of life? Competence, but not autonomy predicts intra-individual fluctuations in subjective well-being in very old age. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *72*, 425-435. https://doi.org/10.1093/geronb/gbv052

Neubauer, A. B., & Voss, A. (2016a). The structure of need fulfillment: Separating need satisfaction and dissatisfaction on between- and within-person level. *European Journal of Psychological Assessment.* Advance online publication. https://doi.org/10.1027/1015-5759/a000326

Neubauer, A. B., & Voss, A. (2016b). Validation and revision of a German version of the Balanced Measure of Psychological Needs Scale. *Journal of Individual Differences*, *37*, 56–72. https://doi.org/10.1027/1614-0001/a000188

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & R. Development Core Team. (2017). *nlme: Linear and nonlinear mixed effects models R. package version 3.1-131.*

Radel, R., Pelletier, L. G., Sarrazin, P., & Milyavskaya, M. (2011). Restoration process of the need for autonomy: the early alarm stage. *Journal of Personality and Social Psychology*, *101*, 919–934. https://doi.org/10.1037/a0025196

Reis, H. T., Sheldon, K. M., Gable, S. L., Roscoe, J., & Ryan, R. M. (2000). Daily well-being: The role of autonomy, competence, and relatedness. *Personality and Social Psychology Bulletin*, *26*, 419–435. https://doi.org/10.1177/0146167200266002

Schilling, O. K., & Diehl, M. (2014). Reactivity to stressor pile-up in adulthood: Effects on daily negative and positive affect. *Psychology and Aging*, *29*, 72–83. https://doi.org/10.1037/a0035500

Sheldon, K. M. (2011). Integrating behavioral-motive and experiential-requirement perspectives on psychological needs: a two process model. *Psychological Review*, *118*, 552–569. https://doi.org/10.1037/a0024758

Sheldon, K. M., Abad, N., & Hinsch, C. (2011). A two-process view of Facebook use and relatedness need-satisfaction: disconnection drives use, and connection rewards it. *Journal of Personality and Social Psychology*, *100*, 766–775. https://doi.org/10.1037/a0022407

Sheldon, K. M., & Filak, V. (2008). Manipulating autonomy, competence, and relatedness support in a game-learning context: New evidence that all three needs matter. *British Journal of Social Psychology*, *47*, 267–283. https://doi.org/10.1348/014466607X238797

Sheldon, K. M., & Gunz, A. (2009). Psychological needs as basic motives, not just experiential requirements. *Journal of Personality*, *77*, 1467–1492. https://doi.org/10.1111/j.1467-6494.2009.00589.x

Sheldon, K. M., & Hilpert, J. C. (2012). The balanced measure of psychological needs (BMPN) scale: An alternative domain general measure of need satisfaction. *Motivation and Emotion*, *36*, 439–451. https://doi.org/10.1007/s11031-012-9279-4

Sheldon, K. M., & Schüler, J. (2011). Wanting, having, and needing: integrating motive disposition theory and self-determination theory. *Journal of Personality and Social Psychology*, *101*, 1106–1123. https://doi.org/10.1037/a0024952

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological Momentary Assessment. *Annual Review of Clinical Psychology*, *4*, 1–32. https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

Sliwinski, M. J. (2008). Measurement-burst designs for social health research. *Social and Personality Psychology Compass*, *2*, 245–261. https://doi.org/10.1111/j.1751-9004.2007.00043.x

Smyth, J. M., Sliwinski, M. J., Zawadzki, M. J., Scott, S. B., Conroy, D. E., Lanza, S. T., . . . Almeida, D. M. (2018). Everyday stress response targets in the science of behavior change. *Behaviour Research and Therapy*, *101*, 20–29. https://doi.org/10.1016/j.brat.2017.09.009

Steinmayr, R., & Spinath, B. (2009). The importance of motivation as a predictor of school achievement. *Learning and Individual Differences*, *19*, 80–90. https://doi.org/10.1016/j.lindif.2008.05.004

Tóth-Király, I., Morin, A. J. S., Bőthe, B., Orosz, G., & Rigó, A. (2017). Investigating the multidimensionality of need fulfillment: A bifactor exploratory structural equation modeling representation. *Structural Equation Modeling: a Multidisciplinary Journal*, *25*, 267–286. https://doi.org/10.1080/10705511.2017.1374867

Trull, T. J., & Ebner-Priemer, U. W. (2009). Using experience sampling methods/ecological momentary assessment (ESM/EMA) in clinical assessment and clinical research: introduction to the special section. *Psychological Assessment*, *21*, 457–462. https://doi.org/10.1037/a0017653

Vansteenkiste, M., Lens, W., Soenens, B., & Luyckx, K. (2006). Autonomy and relatedness among Chinese sojourners and applicants: Conflictual or independent predictors of well-being and adjustment? *Motivation and Emotion*, *30*, 273–282. https://doi.org/10.1007/s11031-006-9041-x

Voelkle, M. C., Oud, J. H. L., Davidov, E., & Schmidt, P. (2012). An SEM approach to continuous time modeling of panel data: Relating authoritarianism and anomia. *Psychological Methods*, *17*, 176–192. https://doi.org/10.1037/a0027543

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063

Weiss, P., Wertheimer, M., & Groesbeck, B. (1959). Achievement Motivation, Academic Aptitude, and College Grades. *Educational and Psychological Measurement*, *19*, 663–666. https://doi.org/10.1177/001316445901900424

Table 1

Variance Components of Empty Three-Level Models.

	Autonomy			Competence			Relatedness		
	Sat	Dis	Mot	Sat	Dis	Mot	Sat	Dis	Mot
Level 3	.472	.829	.935	.611	.921	1.414	1.036	.661	1.208
(Across Persons)	(18.5%)	(26.6%)	(37.9%)	(28.7%)	(33.0%)	(45.8%)	(28.2%)	(27.3%)	(45.8%)
Level 2	.388	.303	.249	.235	.297	.328	.536	.367	.260
(Across Days)	(15.2%)	(9.7%)	(10.1%)	(11.0%)	(10.7%)	(10.6%)	(17.3%)	(15.2%)	(9.9%)
Level 1	1.686	1.988	1.284	1.286	1.573	1.342	1.999	1.390	1.170
(Within Days)	(66.2%)	(63.7%)	(52.0%)	(60.3%)	(56.3%)	(43.5%)	(54.4%)	(57.5%)	(44.4%)

Note. Table depicts variance estimates of the nine study variables (proportion of variance relative to the total variance in brackets). Sat = satisfaction; Dis = dissatisfaction; Mot = motivation.

Table 2

Descriptive Statistics.

	Measure	1	2	3	4	5	6	7	8	9	*SD (Level 3)*	*Mean*
1	Autonomy Sat	-	-.59***	.35*	.18	-.63***	.11	.32*	-.57***	.23	0.68	4.76
2	Autonomy Dis	-.56*** -.34***	-	-.00	-.02	.72***	.08	-.04	.70***	.05	0.90	2.39
3	Autonomy Mot	-.06 .01	.31* .00	-	.16	-.16	.33*	.42**	-.07	.72***	0.96	5.01
4	Competence Sat	-.06 .02	.19 .05	.02 .01	-	-.35*	.61***	.72***	-.28*	.09	0.78	3.63
5	Competence Dis	-.35*** -.25***	.36** .29***	.00 .02	-.16 -.10*	-	-.09	-.34**	.72***	-.01	0.95	2.74
6	Competence Mot	.01 .04	.26* .03	.39** .09**	.47*** .18***	-.15 -.02	-	.46***	-.11	.36*	1.18	3.57
7	Relatedness Sat	.35** .18***	-.04 -.05	-.22* .01	.04 .13***	-.37** -.12***	.12 .05	-	-.30*	.36*	1.01	4.42
8	Relatedness Dis	-.26* -.11***	.40** .20***	-.10 -.05	.06 -.05	.63*** .15***	.01 -.00	-.23* -.05	-	-.01	0.80	2.16
9	Relatedness Mot	.06 .03	.07 -.03	.14 .19***	-.21* -.02	.26 .01	-.08 .02	.11 .04	.25 -.04	-	1.09	5.40
	SD (Level 2)	0.63	0.55	0.50	0.47	0.56	0.57	0.81	0.62	0.51		
	SD (Level 1)	1.30	1.41	1.13	1.14	1.25	1.16	1.41	1.18	1.08		

Note. Table depicts product-moment correlations as well as means and standard deviations. Sat = satisfaction; Dis = dissatisfaction; Mot = motivation. Results in the upper diagonal depict between-person associations (Level 3). Results in the lower diagonal depict within-person associations. The first correlation in these cells refer to the between-day level (Level 2), the second correlation to the within-day level (Level 1). $N = 58$; number of unique person days = 287; total number of observations = 2,257. *$p < .05$; **$p < .01$; ***$p < .001$.

Table 3

Results of the Multilevel Models Predicting Momentary Motivation (Left Panel) and Momentary Satisfaction (Right Panel).

		Motivation			Satisfaction		
		Autonomy	Competence	Relatedness	Autonomy	Competence	Relatedness
		Fixed Effects					
Intercept	π_0	4.99*** (.134)	3.56*** (.142)	5.41*** (.148)	4.79*** (.081)	3.68*** (.092)	4.46*** (.140)
Person Level							
Satisfaction	π_1	0.60** (.212)	0.97*** (.181)	0.31* (.138)	-	-	-
Dissatisfaction	π_2	0.33 (.169)	0.21 (.149)	0.11 (.177)	-0.44*** (.085)	-0.23* (.092)	-0.29 (.161)
Motivation	π_3	-	-	-	0.24** (.082)	0.33*** (.077)	0.26* (.124)
Across Days							
Satisfaction (Today)	γ_1	-0.01 (.068)	0.35*** (.091)	0.15** (.054)	-	-	-
Dissatisfaction (Today)	γ_2	0.09 (.075)	-0.06 (.069)	0.23** (.073)	-0.61*** (.077)	-0.04 (.060)	-0.45*** (.108)
Motivation (Today)	γ_3	-	-	-	0.03 (.100)	0.34*** (.067)	0.33** (.122)
Satisfaction (Yesterday)	γ_4	-0.04 (.069)	-0.03 (.087)	-0.04 (.055)	-0.03 (.081)	-0.14 (.075)	-0.07 (.083)
Dissatisfaction (Yesterday)	γ_5	-0.05 (.069)	-0.03 (.076)	-0.18** (.067)	-0.11 (.081)	0.08 (.066)	0.11 (.104)
Motivation (Yesterday)	γ_6	0.07 (.072)	-0.02 (.075)	-0.14 (.078)	0.04 (.086)	-0.01 (.066)	0.24* (.117)
Within Days							
Satisfaction (Now)	β_1	0.00 (.025)	0.18*** (.029)	0.00 (.022)	-	-	-
Dissatisfaction (Now)	β_2	0.00 (.024)	0.02 (.026)	-0.04 (.027)	-0.31*** (.025)	-0.13*** (.026)	-0.09* (.035)
Satisfaction (Previous Beep)	β_3	-	-	-	0.04 (.027)	-0.07* (.028)	0.12*** (.028)
Motivation (Previous Beep)	β_4	-0.04 (.028)	-0.02 (.029)	-0.04 (.028)	-0.02 (.031)	0.07* (.029)	0.01 (.037)
		Random Effects					
Intercept Level 3 (Across Persons)	Var(υ_j)	0.944	1.045	1.157	0.244	0.404	0.870
Intercept Level 2 (Across Days)	Var(ζ_{dj})	0.164	0.216	0.233	0.278	0.127	0.676
Residual Variance (Within Days)	Var(ε_{idj})	1.196	1.293	1.124	1.453	1.236	1.855

Note. Table depicts fixed effect estimated in the upper panel (standard errors in brackets), and estimates of the random variances in the lower panel. Please note that the variance estimates are not directly comparable to the variance estimates in Table 1, since occasions with missing values on lagged variables were excluded here, but not in Table 1. Number of participants = 58; number of unique person days = 227; total number of observations = 1,457 - 1,505. *$p < .05$, **$p < .01$, ***$p < .001$.

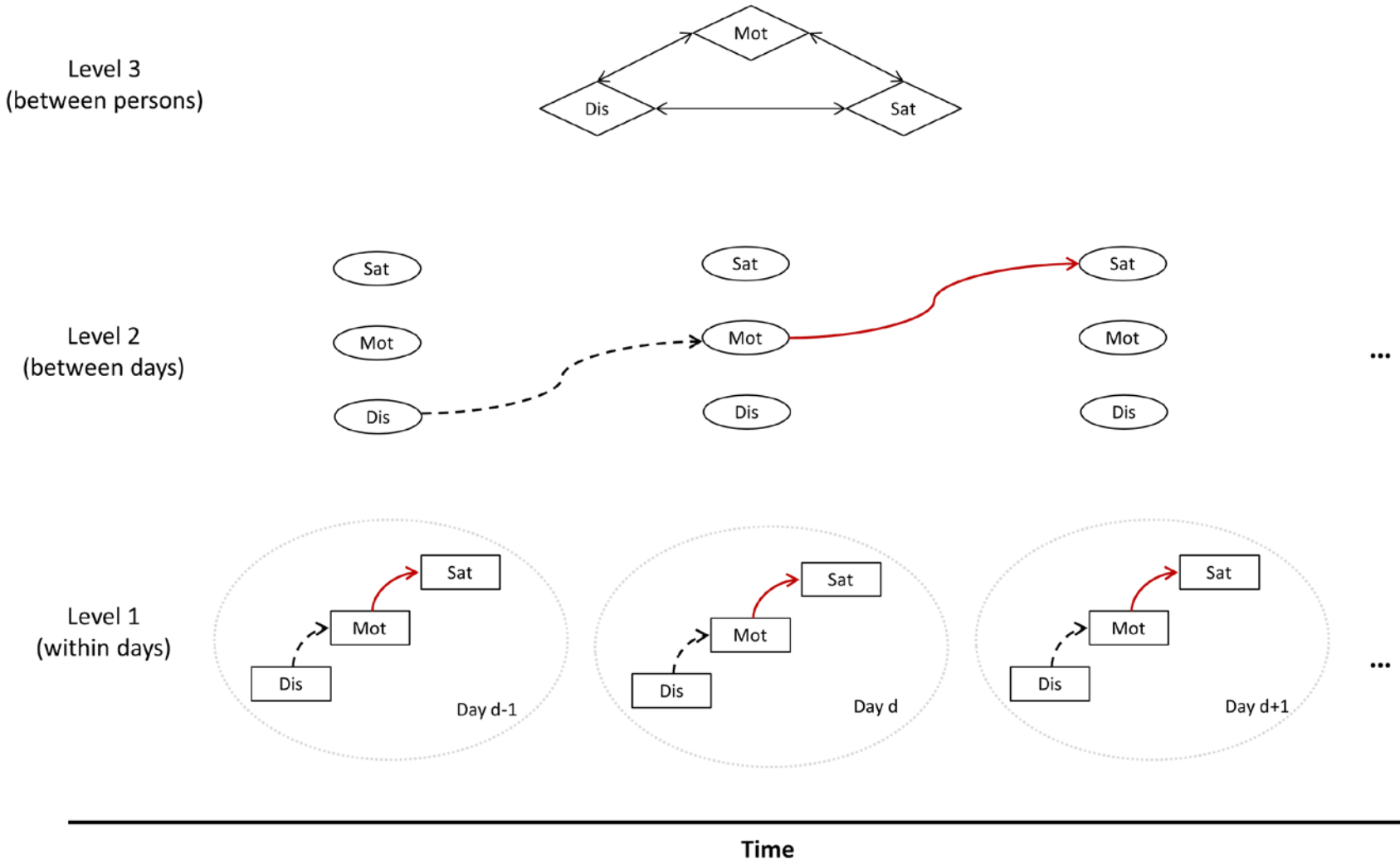
Level 3
(between persons)
Mot
Dis
Sat
Level 2
(between days)
Sat
Mot
Dis
Sat
Mot
Dis
Sat
Mot
Dis
...
Level 1
(within days)
Sat
Mot
Dis
Day d-1
Sat
Mot
Dis
Day d
Sat
Mot
Dis
Day d+1
...
Time

Figure 1. Figure depicts the postulated associations of need dissatisfaction (dis), need motivation (mot), and need satisfaction (sat). The rectangles in the lower row (Level 1) depict momentary states of these three variables. Need dissatisfaction is expected to predict subsequent need motivation on the same day (dashed black arrow; Hypothesis 1) and need motivation is expected to predict subsequent need satisfaction on the same day (solid red arrow; Hypothesis 2). The circles in the middle row (Level 2) represent a person's mean of the three variables on a given day. Need dissatisfaction is expected to predict need motivation on the next day (dashed black arrow; Hypothesis 1) and need motivation is expected to predict need satisfaction on the next day (solid red arrow; Hypothesis 1). The diamonds in the upper row (Level 3) represent a person's mean of the three variables across the whole five days.