Preregistration Protocol: Smartphone Sensing Panel Study (SSPS)

This preregistration protocol deals with specific research questions and is completed after the data has already been collected. As part of the preparation of a technical infrastructure for the overall SSPS project, one of the authors already had access to the raw smartphone sensing data before preregistering this research question. However, the author has not yet processed the data. Instead, a test dataset with sensing data of one project member of the PhoneStudy team was used to specify the pre-registered variables. However, this test dataset did not contain any questionnaire data and will not be part of the final dataset analyzed in the scope of this project. Study procedures and further background information are described in the corresponding basic protocol[1]. This template is inspired by the OSF Prereg Challenge template [2].

Working Title
Everyday fragmentation through smartphone usage and affective well-being

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Background

Background Information (Optional; Short description of the theoretical background/introduction to research question)
Smartphone usage might interfere with and interrupt offline activities (Klimmt, Hefner, Reinecke, Rieger, & Vorderer, 2018; Kushlev, 2018). These interruptions can be exogenous

[1] https://psycharchives.org/handle/20.500.12034/2522
[2] https://osf.io/

(triggered by notifications) or endogenous (checking behaviors, self-interruptions) (Wilmer, Sherman & Chein, 2017). The resulting distraction and “disengagement from the unmediated environment” (Kushlev, 2018) can pose a threat to psychological well-being.
For example, not focusing on the present moment but being distracted decreases positive affect that can be derived from positive experiences (Quoidbach, Berry, Hansenne, & Mikolajczak, 2010). In addition, not being fully present during social interactions is potentially particularly detrimental as one is failing to really connect and to derive the benefits of social interactions (Dwyer, Kushlev, & Dunn,2018; Kushlev, K., & Dunn,2019; Kushlev, & Heintzelman, 2018) and might harm relationships in the long run (Al-Saggaf, Y., & O'Donnell, 2019; Roberts & David, 2016) hence, diminishing a major source of well-being (e.g., Misra et al., 2014). Besides, a state of “flow” can only be reached in times of intense focus on the activity at hand (Csikszentmihalyi, 1990; Fitz et al., 2019). But task switching (multitasking) and interruptions increase cognitive load which in turn can create stress, negative or less positive emotions, undermine performance, increase inattention, and hinder emotion regulation (Fitz et al., 2019; Kushlev, & Dunn, 2015; Zijlstra, Roe, Leonora, & Krediet, 1999). Finally, potentially rewarding engagement with the environment like social interactions with strangers, e.g., asking for directions (Kushlev, Proulx, & Dunn, 2017) or while waiting (Kushlev, Hunter, Proulx, Pressman, & Dunn, 2019) are substituted by smartphone usage.

So far, the focus in the literature on the effects of smartphone usage and well-being is on total time of usage or usage at specific times of the day (nighttime usage) (e.g., Twenge & Campbell, 2018). However, we hypothesize that not necessarily longer periods of smartphone usage but the continuous small interruptions during daily life are detrimental to our well-being. Longer periods of smartphone use hold the potential for gratifying activities like high- quality social interactions or relaxation and entertainment. Longer periods of usage might be more comparable to other media use like watching TV, reading a newspaper or calling somebody with the same benefits and risks. However, the constant shift in focus and attention from the unmediated engagement with the environment to the world within the smartphone is an entirely new phenomenon.

Research question(s)

Is fragmentation of everyday life through smartphone usage associated with affective-well-being?

Hypotheses
Please provide hypothesis for predicted results. If multiple hypotheses, uniquely number them (e.g. H1, H2a, H2b,) and refer to them the same way at other points in the registration document and in the manuscript.

We have one main hypothesis, which we will investigate on an inter- and intra-individual level using a multiverse of plausible operationalizations for both predictors and outcomes (see next section):

Individuals with higher fragmentation of everyday life through smartphone usage have lower well-being on average. (inter-individual perspective)

Time periods with higher fragmentation through smartphone usage in daily life are associated with lower well-being. (intra-individual perspective)

Variables

Which variables will be used? (see Variables in the basic protocol for an extensive overview of all available variables)
This section shall be used to unambiguously clarify which variables are used to operationalize the specified hypotheses. Please (a) list all variables that will be used in this study and (b) explicitly state the functional role of each variable (i.e., independent variable, dependent variable, covariate, mediator, moderator). It is important to (c) specify for each hypothesis how it is operationalized, i.e., which variables will be used to test the respective hypothesis and how the hypothesis will be operationally defined in terms of these variables. This section is closely related to the statistical models used to test the hypotheses.

Control Variables:

- Total Wake Time
  - Time between self-reported time waking up and going to bed (duration)
- Total Non-Smartphone Time
  - Total amount of wake time minus smartphone usage time during this time (duration)
- Total Smartphone Time
  - Total amount of smartphone usage time in a day (duration)

Predictors:

- Quadratic Non-Smartphone Time
  - Squared interval lengths summed up and divided by square of total non-smartphone time
  - Range: 1 = “there is no interruption at all” to approaching 0 = “the time is split into super small intervals”
  - Rationale: How much of the non-smartphone time is spent in longer non-interrupted intervals? The squared term reflects the idea that longer intervals without interruption are more valuable

- Quadratic Smartphone Time
  - Squared interval lengths summed up and divided by the squared total of smartphone usage time
  - Range: 1 = “all smartphone usage takes place in one chunk” to approaching 0 = “the time is split into super small intervals”
  - Rationale: Just as with non-smartphone-time, we hypothesize that smartphone usage in bigger chunks allows for more valuable usage experiences.

- Median Non-Smartphone Time
  - Median of the duration of all non-smartphone usage intervals of a day
  - Rationale: It is important if non-smartphone time is characterized by rather larger or smaller intervals.

- Median Smartphone Time
  - Median of the duration of all smartphone usage intervals of a day
  - Rationale: It is important if the usage behavior is characterized by rather larger or smaller intervals of smartphone usage.

- Number of Smartphone Usage Intervals
  - Each screen-on event is counted (screen-on events within 30 seconds are counted as one event)
  - Rationale: Is daily life characterized by frequent smartphone usage? Whether the resulting smartphone usage is split up in longer or shorter intervals doesn't matter but simply how often individuals disengage from the immediate environment by using their smartphone.

- Non-Smartphone Time in 5-minute intervals
  - Number of total wake time spent not using a smartphone that was interrupted by smartphone usage after 5 minutes or less
  - Rationale: Non-usage time differs qualitatively depending on whether it is spent in very short chunks (5 min), medium length chunks (6-30 min) or large chunks (more than 30 min)

- Non-Smartphone Time in 6–30-minute intervals
  - Number of total wake time spent not using a smartphone that was interrupted by smartphone usage after more than 5 minutes but less than 31 minutes
  - Rationale: see above

- Non-Smartphone Time in >30-minute intervals
  - Number of total wake time spent not using a smartphone that was not interrupted by smartphone for more than 30 minutes
  - Rationale: see above

- Smartphone Usage in 5-minute intervals
  - Number of total wake time using a smartphone for not more than 5 minutes
  - Rationale: Usage time differs qualitatively depending on whether it is spent in very short chunks (5 min), medium length chunks (6-30 min) or large chunks (more than 30 min)

- Smartphone Usage in 6-30-minute intervals
  - Number of total wake time using a smartphone for more than 5 minutes but less than 31 minutes
  - Rationale: see above

- Smartphone Usage in >30-minute intervals
  - Number of total wake time using a smartphone for more than 30 minutes
  - Rationale: see above

Outcomes

- Well-being as between-person outcome
  - Affective well-being: PANAVA-KS (wave 6)
  - Satisfaction with life: SWLS (wave 6)
  - Flourishing (wave 6)

- Well-being as within-person outcome
  - Mood: valence
  - Mood: arousal

Analysis Plan

Preprocessing

Inclusion criteria (e.g., criteria for including (1) participants (e.g., Do you only use a subsample?, (2) study days (e.g., only weekdays, certain number of study days), (3) any other criteria concerning data quality (e.g., only days with at least x% of logging data) etc.
If you cannot specify these aspects now, please state why.

We will use the data collected during the experience sampling wave 2 (21.09.2020 – 04.10.2020), because it is close in time to survey wave 6, which asks all our between-person criteria at the same time. In addition, we define the following exclusion criteria for our project:

- exclude participants who do not have active usage sessions on 5 out of 7 days the week before the experience sampling session of wave 2
  - Rationale: by doing so, we assure to only use data of valid participants; that means participants who are actively using their smartphone during the study
- exclude days without experience sampling data
  - Rationale: otherwise, we cannot control for total wake time
- exclude days where the app failed to collect any data
  - Rationale: make sure to be able to distinguish between the smartphone was actually not used versus technical logging errors; the latter option should be excluded
- exclude participants from between-person analyses if more than 50% of daily values across the whole study period are missing
  - Rationale: participants need to have at least 7 days of data to aggregate habitual smartphone usage variables

Definition of variables based on smartphone sensing. Please specify your degrees of freedom in variable extraction procedures, e.g.,

- *time information (e.g., what does night, daily, weekend exactly mean?)*
- *Aggregation measures (e.g., measures of central tendency/dispersion).*

If you cannot specify these aspects now, please state why.

All measures presented in the section *Variables* will be calculated per individual and per day. For the between-subject analyses, we take the median per individual for all valid days within the 14-day experience sampling period.

For the within-subject analyses, these measures are calculated for a period before each experience sampling schedule point:

- Time period that starts with a change of activity (smartphone usage to non-usage or the other way around) that appeared at least 2 hours before the measurement and ends with the measurement
- or if wake time before measurement is less than 2 hours all the time before the measurement
- measurement points with less than 1 hour wake time before the measurement point are excluded

Further preprocessing steps (e.g., transformation of data, handling of missing data/outliers etc.)

We only use complete cases for between-person analysis and listwise deletion for within-person analysis.
To handle the issue of multi-collinearity, we will z-standardize predictor variables for between-person analysis. For within-person analysis, we will center level 1 predictors around the individual mean and enter the individual mean as level 2 predictor (Curran & Bauer, 2011).

Data Analysis

Statistical models
Please specify the statistical model (e.g. t-test, ANOVA, LMM) or algorithms that will be used to test each of your hypotheses. Give all necessary information about model specification (e.g., variables, interactions, planned contrasts) and follow-up analyses. Include model selection criteria (e.g., fit indices), corrections for multiple testing, and tests for statistical

violations, if applicable. Please also indicate Inference Criteria (e.g., p-values, effect sizes, performance measures etc.).

We specify a multiverse of multiple regression models for <u>between-person outcomes</u> as follows (hypothesis 1):

- <u>Basic model:</u>
  - **Well-being ~ Total Wake Time + Total Smartphone Time**
  - Hypotheses:
    - Total wake time has a small negative effect on well-being.
    - Total smartphone usage has a small negative effect on well-being.
- <u>Quadratic model:</u>
  - **Well-being ~ Total Wake Time + Total Smartphone Time + Quadratic Non-Smartphone Time + Quadratic Smartphone Usage Time**
  - Hypotheses:
    - Total wake time has a small negative effect on well-being.
    - Total smartphone usage has a small negative effect on well-being.
    - Controlling for total wake time and total smartphone usage, participants' well-being is higher the larger the intervals of non-smartphone time or smartphone usage are.
    - The effect is more pronounced for non-smartphone time.
- <u>Median model:</u>
  - **Well-being ~ Total Wake Time + Total Smartphone Time + Median Smartphone Time + Median Non-Smartphone Time**
  - Hypotheses:
    - Total smartphone usage has a small negative effect on well-being.
    - Total wake time has a small negative effect on well-being.
    - Controlling for total wake time and smartphone usage, participants' well-being is higher the more both their non-smartphone time as well as their smartphone time is characterized by longer periods.
    - The effect is more pronounced for non-smartphone time.
- <u>Frequency model:</u>
  - **Well-being ~ Total Wake Time + Total Smartphone Time + Number of Smartphone Usage Intervals**
  - Hypotheses:
    - Total wake time has a small negative effect on well-being.
    - The more often individuals disengage from the immediate environment (= use their smartphone) the lower their well-being.
- <u>Fixed Lengths model:</u>
  - **Well-being ~ Total Wake Time + Non-Smartphone Time (5 min) + Non-Smartphone Time (5-30) + Non-Smartphone Time (30+) + Smartphone Time (5 min) + Smartphone Time (5-30) + Smartphone Time (30+)**
  - Hypotheses
    - The more time is spent in longer intervals (both non-smartphone and smartphone time) the higher the well-being.
    - The effect is more pronounced for non-smartphone time.

→ each of the above-mentioned models will be used for all of the three between-person outcomes. This finally results in a multiverse of 3 (outcome variants) x 5 (predictor variants) = 15 models.

We specify a multiverse of multilevel regression models for within-person outcomes as follows (hypothesis 2): [3]

- Basic model:
  - **Mood ~ Total Wake Time + Total Smartphone Time**
  - Hypothesis:
    - Mood is less positive the higher the total smartphone usage.
- Quadratic model:
  - **Mood ~ Total Wake Time + Total Smartphone Time + Quadratic Non-Smartphone Time + Quadratic Smartphone Time**
  - Hypotheses:
    - Mood is less positive the higher the total smartphone usage.
    - Controlling for total wake time and total smartphone usage, participants' mood is more positive the larger the intervals of non-smartphone time or smartphone usage are.
    - The effect is more pronounced for non-smartphone time.
- Median model:
  - **Mood ~ Total Wake Time + Total Smartphone Time + Median Smartphone Time + Median Non-Smartphone Time**
  - Hypotheses:
    - Mood is less positive, the higher the total smartphone usage.
    - Controlling for total wake time and smartphone usage, participants' mood is more positive the more both their non-smartphone time as well as their smartphone time is characterized by longer periods.
    - The effect is more pronounced for non-smartphone time.
- Frequency model:
  - **Mood ~ Total Wake Time + Total Smartphone Time + Number of Smartphone Usage Intervals**
  - Hypotheses:
    - The more often individuals disengage from the immediate environment (= use their smartphone) the less positive is their mood.
- Fixed Lengths model:
  - **Mood ~ Total Wake Time + Non-Smartphone Time (5 min) + Non-Smartphone Time (5-30) + Non-Smartphone Time (30+) + Smartphone Time (5 min) + Smartphone Time (5-30) + Smartphone Time (30+)**
  - Hypotheses:
    - The more time is spent in longer intervals (both non-smartphone and smartphone time) the more positive the mood.
    - The effect is more pronounced for non-smartphone time.

[3] (For the sake of clarity, the predictors are named analogously to the predictors of hypothesis 1. Here, however, they do not refer to the entire day, but to the interval before the respective experience sampling time, see section preprocessing).

→ each of the above-mentioned models will be used for all of the two within-person outcomes. This finally results in a multiverse of 2 (outcome variants: arousal, mood) x 5 (predictor variants) = 10 models.

Although we have a specific hypothesis, we consider our analysis exploratory because there are many plausible alternatives in terms of the use of predictors, outcomes, and thus models. However, based on the literature so far, we do not feel able to make an informed choice of one single operationalization of our hypothesis to test only this. Accordingly, we will present a multiverse of findings and not rely on conventional inference criteria. That means, we will not interpret our results on a finding-by-finding basis but the effect size patterns across predictors and outcomes.

Planned exploratory analysis (Optional)
Currently not planned.