Preregistration Protocol: Smartphones as mood barometers - Predicting mood in daily life using different sensing modalities

**Table 1**

*Overview of sensing modalities and related feature categories*

| Sensing modality/ feature category | Feature(s) |
|---|---|
| Communication | |
| Calls*** | <ul><li>total number of calls; total duration of calls; min duration of calls; max duration of calls; mean duration of calls; variation of duration of calls</li><li>total number of outgoing calls; total duration of outgoing calls; min duration of outgoing calls; max duration of outgoing calls; mean duration of outgoing calls; variation of duration of outgoing calls</li><li>total number of incoming calls; total duration of incoming calls; min duration of ringing of incoming calls; max duration of ringing of incoming calls; mean duration of ringing of incoming calls; variation of ringing of incoming calls; min duration of incoming calls; max duration of incoming calls; mean duration of incoming calls; variation of duration of incoming calls</li><li>total number of missed calls; total duration of ringing of missed calls; min duration of ringing of missed calls; max duration of ringing of missed calls; mean duration of ringing of missed calls; variation of duration of ringing of missed calls</li><li>total number of rejected calls; total duration of ringing of missed calls; min duration of ringing of rejected calls; max duration of ringing of rejected calls; mean duration of ringing of rejected calls; variation of duration of ringing of rejected calls</li></ul> |
| Text messages | <ul><li>total number of texts; min length of texts; max length of texts; mean length of texts; variation of length of texts</li></ul> |

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|  |  |
|---|---|
| Keyboard logging[a)] | <ul><li>total number of outgoing texts; min length of outgoing texts; max length of outgoing texts; mean length of outgoing texts; variation of length of outgoing texts</li><li>total number of incoming texts; min length of incoming texts; max length of incoming texts; mean length of incoming texts; variation of length of incoming texts</li><li>min amount of words per message; max amount of words per message; mean amount of words per message; variation of amount of words per message</li><li>min average sentiment of words; max average sentiment of words; mean of average sentiment of words; variation of average sentiment of words</li><li>min score of "LIWC dimension"*; max score of "LIWC dimension"*; mean score of "LIWC dimension"*; variation of score of "LIWC dimension"*</li></ul> |

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Smartphone usage

|  |  |
|---|---|
| Connectivity | <ul><li>total duration of power cable status *connected*</li><li>total duration of flight mode status *on*</li><li>total number of Bluetooth status changes</li><li>total duration of Bluetooth status *on* and *connecting/-ed*</li><li>total duration of Bluetooth status *on* and *disconnected*</li><li>total duration of Bluetooth status *off*</li><li>total duration connected with "device category"*</li><li>total number of WiFi status changes</li><li>total duration of WiFi status *on* and *connecting/-ed*</li><li>total duration of WiFi status *on* and *disconnected*</li></ul> |

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- total duration of WiFi status *off*

- total duration of headphone status *plugged*

Screen

- total number of sessions; total duration of sessions; min duration of sessions; max duration of sessions; mean duration of sessions; variation of duration of sessions

- total number of checks; total duration of checks; min duration of checks; max duration of checks; mean duration of checks; variation of duration of checks

- ratio between total number of checks and total number of sessions; ratio between total duration of checks and total duration of sessions

- first screentime of day; last screentime of day; total duration of screen inactivity at night before; total number of checks during night before; total duration of sessions during night before

Apps

- total number of all app usages; total duration of all app usages; total number of different apps used; min total number of usages per app; max total number of usages per app; mean total number of usages per app; variation of total number of usages per app; min total usage duration per app; max total usage duration per app; mean total usage duration per app; variation of total usage duration per app

- total number of different app categories used; min number of total usages per app category; max number of total usages per app category; mean number of total usages per app category; variation of number of total usages per app category; min total usage duration per app category; max total usage duration per app category; mean total usage duration per app category; variation of total usage duration per app category

- total number of usages of "app category" apps*; total usage duration of "app category" apps*

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| Notification | • total latency of notification caused app usage; min latency of notification caused app usage; max latency of notification caused app usage; mean latency of notification caused app usage; variation of latency of notification caused app usage |
|---|---|

**Music consumption**

| Listening behavior | • total duration of sessions listened to songs; min duration of sessions listened to songs; max duration of sessions listened to songs; mean duration of sessions listened to songs; variation of duration of sessions listened to songs<br>• skipping behavior |
|---|---|
| Songs | • total number of unique listened songs<br>• total number of unique listened artists<br>• total duration of songs listened to; min duration of songs listened to; max duration of songs listened to; mean duration of songs listened to; variation of duration of songs listened to<br>• total level of "Spotify audio feature category" of listened songs*; min level of "Spotify audio feature category" of listened songs*; max level of "Spotify audio feature category" of listened songs*; mean level of "Spotify audio feature category" of listened songs*; variation of level of "Spotify audio feature category" of listened songs* |

**Mobility**

| Places | • total time spent at home; min distance from home; max distance from home; mean distance from home; variation of distance from home<br>• total time spent at work; min distance from work; mean distance from work; variation of distance from work |
|---|---|

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| | |
|---|---|
| Altitude | • min altitude; max altitude; mean altitude; variation of altitude; altitude change; altitude positive change; altitude negative change |
| Geohash | • total number of different Geohashs visited, min time spent per eohash, max time spent per visi |
| Displacement | • radius of gyration; location variance; total distance covered; spatial coverage by convex hull |
| Speed | • min speed; max speed; mean of speed; variation of speed; speed change; total time spent in transit |
| Activity state | • min probability of "activity category"*; max probability of "activity category"*; mean probability of "activity category"*; variation of probability of "activity category"* |

Timestamp

| | |
|---|---|
| Weekday | • current timestamp is at the weekend (vs. weekday) |
| Daytime | • timepoint at morning; timepoint at noon; timepoint at afternoon; timepoint at evening |

Weather

| | |
|---|---|
| Clouds | • cloud coverage of sky; visibility (distance at which objects are visible) |
| Temperature | • dew point temperature<br>• temperature at the location; min temperature; max temperature<br>• feelslike temperature; min feelslike temperature; max feelslike temperature |
| Humidity | • relative humidity |
| Moon | • daily moonphase[a] (fractional portion through current moon lunation cycle) |

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| Precipitation | • amount of precipitation |
|---|---|
| | • snowdepth |
| Sun | • solar radiation power |
| | • UV index |
| | • daily sunrise epoch[a]; daily sunset epoch[a]; daily time difference between sunrise & sunset[a] |
| Wind | • windspeed |
| | • wind direction (in metereological degrees) |

*Note.* All features are created for an hourly time window (i.e. 60 minutes before the experience sampling was started by the participant) and daily time window, except the features labeled with [a] which are only extractable on daily basis; Consequently; all quantification measures (i.e.; total; ratio; min; max; mean; variation) of features are based on logging events within these time windows; All categorical features are dummy coded with 1 = *yes*; 0 = *no*; [a] Keyboard logging features were only extracted for keyboard logs entered in communication apps (inter alia the average sentiment of a text message (SentiWS; Remus et al., 2010) and the Linguistic Inquiry and Word Count (LIWC, Wolf, et al., 2008)); * indicates that this feature will be extracted for each category of the related categorization (i.e.; device categories; app categories; LIWC dimensions; Spotify audio feature category; activity categories) as shown in *Table 2*; ** Level of the Spotify audio features are weighted by listening duration of the respective song; *** Some of the features of the categories *calls, text messages, keyboard logs, apps, screen*, and *notification* will build on previous work by colleagues of the Chair for Psychological Methods and Diagnostics at the Department of Psychology at Ludwig Maximilian University of Munich.

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**Table 2**

*Overview of Categorizations Applied for Feature Extraction*

| Category | Sub-category | Description |
|---|---|---|
| Bluetooth devices | | |
| | Watch | The connected device is a wearable watch. |
| | Headset | The connected device is a headset or headphone. |
| | Phone | The connected device is another smartphone or cordless phone. |
| | Computer | The connected device is a laptop or desktop computer. |
| | Health | The connected device is a health-related wearable, such as weighing or pulse rate measure device. |
| | Car | The connected device is a in car entertainment system. |
| | HiFi | The connected device is a HiFi system or loudspeaker. |
| | Uncategorized | Other connected devices. |
| | n.a. | The connected device reveals no information about its type |
| Apps | | |
| | Social network, gaming, etc. | Adapted from Schoedel et al., (2022) |
| Spotify audio features | | |
| | Danceability | Danceability describes how suitable a track is for dancing based on a combination of musical elements including tempo, rhythm stability, beat strength, and overall regularity. A value of 0.0 is least danceable and 1.0 is most danceable. |

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| | |
|---|---|
| Energy | Energy is a measure from 0.0 to 1.0 and represents a perceptual measure of intensity and activity. Typically, energetic tracks feel fast, loud, and noisy. For example, death metal has high energy, while a Bach prelude scores low on the scale. Perceptual features contributing to this attribute include dynamic range, perceived loudness, timbre, onset rate, and general entropy. |
| Loudness | Relative Loudness of a track compared to other Spotify tracks. The overall loudness of a track in decibels (dB). Loudness values are averaged across the entire track and are useful for comparing relative loudness of tracks. |
| Mode | Mode indicates the modality (major (1) or minor (0)) of a track, the type of scale from which its melodic content is derived. |
| Speechiness | Speechiness detects the presence of spoken words in a track. The more exclusively speech-like the recording (e.g. talk show, audio book, poetry), the closer to 1.0 the attribute value. Values above 0.66 describe tracks that are probably variatione entirely of spoken words. Values between 0.33 and 0.66 describe tracks that may contain both music and speech, either in sections or layered, including such cases as rap music. Values below 0.33 most likely represent music and other non-speech-like tracks. |
| Liveness | Liveness detects the presence of an audience in the recording. Higher liveness values represent an increased probability that the track was performed live. A value above 0.8 provides strong likelihood that the track is live. |
| Valence | A measure from 0.0 to 1.0 describing the musical positiveness conveyed by a track. Tracks with high valence sound more positive (e.g. happy, cheerful, euphoric), while tracks with low valence sound more negative (e.g. sad, depressed, angry). |
| Tempo | The overall estimated tempo of a track in beats per minute (BPM). In musical terminology, tempo is the speed or pace of a given piece and derives directly from the average beat duration. |
| Instrumentalness | Measurement of the likelihood the track is instrumental vs. Predicts whether a track contains no vocals. "Ooh" and "aah" sounds are treated as instrumental in this context. Rap or spoken word tracks are clearly |

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"vocal". The closer the instrumentalness value is to 1.0, the greater likelihood the track contains no vocal content. Values above 0.5 are intended to represent instrumental tracks, but confidence is higher as the value approaches 1.0.

| Activity states | | |
| --- | --- | --- |
| | Still | The device is still (not moving). |
| | In a vehicle | The device is in a vehicle, such as a car. |
| | In a road vehicle | The device is in a vehicle on the road. |
| | In a four-wheeler vehicle | The device is in a vehicle with four wheels (e.g., car) |
| | In a two-wheeler vehicle | The device is in a vehicle with two wheels (e.g., motorcycle) |
| | In a rail vehicle | The device is in a vehicle on rails. |
| | On a bicycle | The device is on a bicycle. |
| | On foot | The device is on a user who is walking or running. |
| | walking | The device is on a user who is walking. |
| | running | The device is on a user who is running. |
| | unknown | Unable to detect the current activity. |