

## Pre-registration Protocol: Smartphone Sensing Panel Study - The Digital Authoritarian

This pre-registration protocol deals with specific research questions and is completed before the data is accessed. Throughout this registration, we will refer to the corresponding basic registration protocol of the panel study. The basic protocol contains information on study procedures and further background information and can be found in the general pre-registration template here: <http://dx.doi.org/10.23668/psycharchives.2901>.

<i>Working Title</i>
The Digital Authoritarian: Theory-Driven Predictions from Everyday Behaviors Collected with Smartphones

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### Background

<i>Background Information (Optional; Short description of the theoretical background/introduction to research question)</i>
Right-wing Authoritarianism (RWA) is on the rise globally (Foa & Mounk, 2016; 2017; Lührmann et al., 2018; Abramowitz, 2018). As a result, researchers are trying to understand how this defining aspect of 20th century history is manifesting in the 21st century digital era. Individual differences in RWA have been studied extensively from a theoretical standpoint (e.g., Duckitt & Sibley, 2009). In addition, a great deal of empirical research has examined the

situational antecedents (e.g., threat) and attitudinal consequences (e.g., prejudice) of authoritarianism (e.g., Perry et al., 2013). However, this theoretical and empirical work has failed to paint a holistic picture of authoritarians' behaviors in daily life. Here, digital traces from smartphone use, which have informed the study of individual differences in other domains (e.g., Stachl, 2020), represent a promising means to investigate the new authoritarians in their daily lives.

Given the importance of understanding this phenomenon in the current geopolitical context, our study will create a theoretically-informed profile of everyday behaviors related to authoritarianism in the digital era. To this end, we drew on the literature to derive a comprehensive overview of empirical reports on behavioral indicators of authoritarianism. We then translated these findings into behavioral features (organized into five interrelated theoretical attributes) which can be captured using data collected from smartphone sensors and logs (e.g., communication, app-use, mobility, music/podcast consumption, physical activity). Where possible, we plan to enrich sensed behavioral data with data from other sources to ensure that our features reflect the theoretical claims about authoritarianism as closely as possible. For example, we will enrich news app usage data with third-party ratings of news sources' quality and political leanings. Lastly, we will use cross-validated machine learning models (i.e., Elastic Net and Random Forest) to determine whether we can predict self-reported authoritarianism from these behavioral features, using data from a representative sample of 749 participants who were tracked continuously for up to six months. To examine the validity of our predictions, we will determine whether our predicted RWA scores correlate with participants' self-reported political orientation and voting behavior.

In addition to advancing theory on authoritarianism, these insights could be used to identify potential authoritarians and deploy interventions that counter authoritarian tendencies (e.g., to decrease reliance on recommendation algorithms that further confirm their worldview). Lastly, we want to provide an example for how research can harness predictive modelling to advance theory (Shrestha et al., 2020; Guest & Martin, 2021) and how theory can advance the interpretability of predictive models.

#### *Research question(s)*

Can we predict self-reported authoritarianism and its facets (i.e., authoritarian aggression, authoritarian submission, and conventionalism) from everyday behavior collected with smartphones? Which theoretically-informed sensing features are most predictive for authoritarianism and its facets?

### *Hypotheses*

*Please provide hypotheses 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.*

Our study is exploratory in nature. The smartphone features we will use in our prediction modelling are derived from the theory and empirical literature on authoritarianism (see The Digital Authoritarian - TheorySensingFeatures.pdf). We pre-register our procedure as a transparent account of our work.

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## 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.*

Data collection occurred as part of a six-month panel study conducted by researchers at Ludwig-Maximilian-Universität München (LMU) in cooperation with Leibniz-Institut für Psychologie (ZPID) from May until November 2020 (for more details see <http://dx.doi.org/10.23668/psycharchives.2901>). Participants downloaded the PhoneStudy research app (which collects data from the phone's sensors and logs) to their personal Android smartphones. All data collection procedures were approved by the ethics board at LMU. The study also included multiple online self-report questionnaires including the German short scale (nine items) on authoritarianism (KSA-3; Beierlein et al., 2014). As a reliability estimate, we will report Cronbach's alpha (with 95% confidence interval).

At the time of pre-registration, the data has already been collected and R scripts for data pre-processing are being prepared. However, except for a test sample (data from a single participant to enable the development of an infrastructure to process the dataset), we have not accessed the data. From records of panel compensation, we know that 749 participants have filled out the questionnaire wave which included the German short scale on authoritarianism.

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## 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 exclude participants who did not complete the entire RWA questionnaire. Moreover, we will exclude participants with less than 15 days of logging data, and we will remove participants who did not use any apps at all.

*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.*

We will aggregate the logged raw phone events into theory-derived sensing features. We have grouped the sensing features into five attributes: preference for simple information that confirms existing beliefs; limited exposure to unknown people, places, and cultures; preference for structure and routines; tendency towards aggression and emotionality; and respect for (followed) authority and hierarchy. The exhaustive list of theory-derived sensing features and their corresponding theoretical attributes is described in detail in the attached document (The Digital Authoritarian - TheorySensingFeatures.pdf).

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

The large amounts of data makes it infeasible to check for outliers manually, so we will use robust estimators (e.g., Huber M Estimator). To avoid overoptimistic performance evaluations

of our models, we will perform as much pre-processing as possible within the resampling scheme. Within nested-resampling we will:

- impute missing values: for Elastic Net models we will use histogram imputation, for Random Forest models we will use outlier imputation (i.e., impute missing values with extreme values to allow trees to split on it; factors > new category, numeric  $2 * \max$ )

(<https://mlr3book.mlr-org.com/pipe-pipeops.html>)

- data transformation: Elastic Net models require predictors to be standardized to perform regularization. Numeric variables will be centered and scaled as part of the glmnet function. Factors will be re-coded into dummy variables.

- (optionally) if our models do not perform above baseline levels (see data analysis), we will additionally test the inclusion of a feature selection module in the resampling procedure. For Random Forest models, we will filter by permutation importance. For Elastic Net models, we will filter by absolute linear correlation with the criterion

(<https://mlr3book.mlr-org.com/fs.html>)

## 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 will train machine learning regression models on the extracted features to predict self-reported overall (mean) RWA score as well as each of the three facets of RWA (i.e., mean of authoritarian aggression, authoritarian submission, and conventionalism) separately. We plan to compare the predictive performance of two algorithms--Elastic Net regularized regression models (Zou & Hastie, 2005) and non-linear tree-based random forest models (Breiman, 2001)--and a baseline model, which would predict the mean value from the training set for all cases in the test set. We will impute missing values, remove constant features (less than 2% different values in the data), and tune model hyperparameters in a nested cross-validation scheme and benchmark the median predictive performance of our models across folds with the baseline.

Our prediction models will be evaluated based on how accurate new (unseen) samples can be predicted. Model fit will be evaluated based on multiple statistical parameters, for example, Pearson correlation ( $r$ ), Spearman correlation ( $\rho$ ), root mean squared error ( $RMSE$ ), mean absolute error ( $MAE$ ), and the coefficient of determination ( $R^2$ ). Further, we plan to run variance- (for example, from Nadeau & Bengio, 2003) and multiple-testing (Holm) corrected significance tests to determine if we can predict authoritarianism significantly above baseline levels.

Furthermore, we will use interpretable machine learning methods. Here, we aim to compute feature importance measures for single features and the five feature groups (the latter weighted by the inverse number of features in the respective attribute group). This will allow us to explore which features are predictive of self-reported authoritarianism. Additionally, we will use permutation importance based significance tests (PIMP) to test the importance of feature-groups (Altmann, 2010). Further, we aim to compute accumulated local effects (ALE) plots and/ or partial dependence plots (PDP) in order to get insights into the direction of feature effects. In order to investigate the validity of our predictions, we correlate participants' predicted mean RWA scores with participants' self-reported political orientation and self-reported voting intentions.

#### *Planned exploratory analysis (Optional)*

-Initial exploratory data analysis - see comment above

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