

Theory-Derived Sensing Features

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This document corresponds to the pre-registration protocol “Smartphone Sensing Panel Study - The Digital Authoritarian.” It describes in detail the theory-derived behavioral features that may be related to each of five authoritarian attributes (see Table 1). These behavioral features were derived in a three-step process. First, we identified the major theoretical claims that have been made about authoritarians and organized them into the five overarching attributes listed below. Although these attributes are presented as distinct categories, they are in fact interrelated and overlapping, as the authoritarian personality is considered to be “a syndrome” of attributes that cluster together in a person (Adorno et al., 2019/1950). Second, we collected empirical evidence from the authoritarianism literature that supports each theoretical attribute. We focused on evidence regarding authoritarians’ behaviors because smartphone sensing methods are particularly well-suited for recording behavior. Third, we translated these theoretically supported empirical findings into behavioral features that can be computed using data collected from smartphone sensors and logs and enriched from other sources. Enriching the sensed data will allow us to compute features that hew more closely to theoretical claims about authoritarians than would be possible by relying on sensed data alone.

1. [Preference for simple information that confirms existing beliefs](#)
2. [Limited exposure to unknown people, places, and cultures](#)
3. [Preference for structure and routines](#)
4. [Tendency towards aggression and emotionality](#)
5. [Respect for \(followed\) authority and hierarchy](#)

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Table 1. *Theoretical statements & empirical evidence on behavioral correlates of RWA used to derive smartphone sensing features.*

Author (year)	Theoretical statement(s)	Empirical evidence	Sensing features
<i>Attribute 1: Preference for simple information that confirms existing beliefs</i>			
Altemeyer (1998)	“High RWAs' thinking, based more on memorization of what authorities have told them than on independent critical appraisal, tends to be unintegrated, highly compartmentalized, and rife with inconsistencies.” (p. 86)	– Self-reported number of different news sources (e.g., TV, Radio) consumed (Sindermann et al., 2020)	<i>Use of news apps^{1*}</i> <ol style="list-style-type: none"> 1) App category features 2) Single app features (e.g., “Tagesschau”, “Russia Today”) 3) App category features for foreign news apps 4) App category features for non-German language news apps 5) App category features for alternative news apps 6) Mean, SD, skew, kurtosis, min, max political bias in news apps 7) Mean, SD, skew, kurtosis, min, max quality in news apps <p>*foreign defined as media outlets with main headquarters located outside of Germany; political bias of apps in this category enriched with information from Garz et al., 2020; quality scores from https://medienkompass.org/deutsche-medienlandschaft/; alternative news coded using information from</p>
Altemeyer (1996)	“They [High RWAs] subsequently maintain their beliefs [...] surrounding themselves with sources of information that will tell them they are right.” (p.111)	– Data selection when given the choice to access summaries of information (Tullet et al., 2016, supplementary materials)	
Altemeyer (1998)	“Adult authoritarians tend to be highly ethno- centric and heavy users of the ‘consensual validation pill’ (Newcomb, 1961). They travel in tight circles of like-minded people so much, they often think their views are commonly held in society, that they are the ‘Moral Majority’ or the ‘Silent Majority.’” (p.78)	+ Consumption of conservative (Fox News) and broadcast (ABC, NBC, and CBS) news outlets (Morgan & Shanahan, 2017)	
Altemeyer (2007)	“The ethnocentrism of high RWAs makes them quite vulnerable to unscrupulous manipulators.” (p. 89)	+ Consumption of conservative news outlets (e.g., Fox News) (Peterson et al., 2018; Iyengar & Hahn, 2009) ^a + Political engagement (Federico et al., 2017)	
		– Consumption of liberal news outlets (e.g., npr) (Peterson et al., 2018; Iyengar & Hahn, 2009) ^a	

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<p>Montuori (2005)</p>	<p>“A consistent attempt to reduce complexity through maladaptive simplicity is characteristic of the closed-mindedness of the authoritarian personality. It manifests in the suppression of discourse that reflects a plurality of views, strangled by the fear created by the perception of anxiety in emergency.” (p. 23)</p>	<p>+ General TV watching (Shanahan, 1995/1998, Morgan & Shanahan, 2017)</p> <p>+ Cognitive rigidity (e.g., Zmigrod et al., 2018; van Hiel et al., 2016)</p> <p>– Use of fewer analytic words, indicative of less cognitive complexity (Faulkner & Bliuc, 2018)</p>	<p>https://www.newsguardtech.com/de/bewertungen/bewertungsprozess-und-kriterien/</p> <p><i>Use of social media apps¹</i></p> <ol style="list-style-type: none"> 1) App category features 2) Single app features (e.g., Facebook, Instagram) <p><i>Use of apps for movie/video watching¹</i></p> <ol style="list-style-type: none"> 1) App category features 2) Single app features (e.g., Netflix) <p><i>Use of reading apps¹</i></p> <ol style="list-style-type: none"> 1) App category features 2) Single app features (e.g., Kindle) <p><i>Use of apps distributed by political parties^{1*}</i></p> <ol style="list-style-type: none"> 1) App category features 2) Mean, SD, skew, kurtosis, min, max political orientation of political apps installed 3) Single app features (e.g., AfD, CDU) <p>*political orientation of parties in this category enriched with information from https://manifesto-project.wzb.eu/information/documents/information.</p>
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			<p><i>Use of search apps¹</i></p> <ol style="list-style-type: none">1) App category features2) Single app features (e.g., Google Search, DuckDuckGo, Ecosia) <p><i>Use of apps for listening to music/ podcasts¹</i></p> <ol style="list-style-type: none">1) App category features2) Single app features (e.g., Spotify, Audible) <p><i>Podcast preferences (across apps)^{*3}</i></p> <ol style="list-style-type: none">1) Daily mean, SD, skew, kurtosis, min, max duration listening to podcasts2) Daily mean, SD, skew, kurtosis, min, max duration listening to podcast genres (two genre levels: e.g., Christianity and religion) from total podcast listening duration3) Entropy in podcast genres in study period <p>*podcast genres identified matching the podcast name to the iTunes podcast genre taxonomy retrieved from https://podcasts.apple.com/de/genre/podcasts/id26 with a crawler: https://github.com/mdg/itunes-podcast-crawler</p>
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			<p><i>Linguistic features of typed words²</i></p> <p>1) LIWC2015 category (and respective subcategories): Cognitive processes; Analytic Thinking</p>
<p><i>Attribute 2: Limited exposure to unknown people, places, and cultures</i></p>			
<p>Altemeyer (2007)</p>	<p>“...high RWA students had simply missed many of the experiences that might have lowered their authoritarianism. [...] They simply had not met many different kinds of people or done their share of wild and crazy things. Instead they had grown up in an enclosed, rather homogeneous environment—with their friends, their schools, their readings, their amusements all controlled to keep them out of harm’s way and Satan’s evil clutches. They had contentedly traveled around on short leashes in relatively small, tight, safe circles all their lives.”(p. 61)</p>	<p>– Frequency of contact with outgroup members (Dhont & van Hiel, 2009, 2011)</p> <p>– Proportion of users of a global online dating platform (Huber & Malhotra, 2017^a)</p> <p>– Possession of objects related to foreign cultures (e.g., maps, CDs, books, travel tickets) (Carney et al., 2008^a)</p> <p>+ Interest in popular music genres (Peterson & Pang, 2006)</p> <p>+ Expressions of past orientation and use of “we” in tweets (Sterling et al., 2020)^a. Note: Hypotheses in Sterling et al., 2020 were based on Jost, 2019 and Vasilopoulos et al., 2019.</p>	<p><i>Phone contacts</i></p> <p>1) Number of contacts at beginning of study</p> <p>2) Number of contacts added during study period</p> <p>3) Number of foreign numbers in contacts (determined by country code)</p> <p>4) Entropy of contacts for outgoing calls and texts</p> <p>5) Entropy of contacts for incoming calls and texts</p> <p>6) Entropy of contacts for missed calls</p> <p><i>GPS variety</i></p> <p>1) Mean radius of gyration on weekdays</p> <p>2) Mean maximum distance between two locations on weekdays (Monday-Friday)</p> <p>3) Total distance covered on weekdays</p> <p>4) Mean percentage of time spent at home* on weekdays</p> <p>5) Mean radius of gyration on weekends (Saturdays/Sundays)</p>
<p>Altemeyer (1996)</p>	<p>“The trouble is, most High RWAs had never (knowingly) met a homosexual. Nor, they said, had they gotten to know any dissenters or "unpatriotic" or nonreligious people either. They had had no close contact with nontraditional families. They had not taken advantage</p>		

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<p>Dhont & van Hiel (2009)</p> <p>Selimbegovic et al. (2013)</p>	<p>of the greater freedom young people have to explore and experiment. They had not broken rules, smoked things they should not smoke, or read verboten magazines under the covers by flashlight. They had not learned that their parents did not always know what was best for them, in their era with its new problems and angst. They had not had rebellious ideas or done unconventional things, and they were not friends with those who did.” (p.78)</p> <p>“...it can be expected that if authoritarians [...] would have a free choice to interact, they would avoid intergroup contact.” (p. 173)</p> <p>“... [authoritarian individuals] ...should be particularly likely to use contemporary popular music originating from their culture as a method of worldview defense.” (p. 107)</p>	<p>+ Preference for past-focused, nostalgic communication (Baldwin & Lammers, 2016; Lammers & Baldwin, 2018)^a</p> <p>– Openness to experience (Ekehammari, et al., 2004; Silvia et al., 2021; Obschonka et al., 2018; Hotchin & West, 2018)</p> <p>+ Greater use of words related to loyalty, purity, and pronouns reflecting group identification (i.e., first and third person pronouns) (Faulkner & Bliuc, 2018; Kugler, Jost, & Noorbaloochi, 2014)</p>	<p>6) Entropy in places visited 7) Mean maximum distance between two locations on weekends 8) Total distance covered on weekends 9) Mean percentage of time spent at home on weekends</p> <p>*home identified by the location cluster the participant spends most of their time between 2:00am and 4:00am on weekdays.</p> <p><i>Use of travel apps^l</i></p> <p>1) App category features 2) Single app features (e.g., Lonely Planet)</p> <p><i>Use of language learning apps^l</i></p> <p>1) App category features 2) Single app features (e.g., Duolingo, Babbel)</p> <p><i>Use of dating apps^l</i></p> <p>1) App category features 2) Single app features (e.g., Tinder, Bumble) 3) App category feature - apps targeted to non-normative sexual preferences (e.g., Grindr, Kinkd, Yumiapp)*</p> <p>*dating apps to be coded on this dimension by independent raters</p>
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			<p style="text-align: center;"><i>Use of apps for the local area¹</i></p> <ol style="list-style-type: none"> 1) App category features 2) Single app features (e.g., Heimat-App, Heimat24) <p style="text-align: center;"><i>Music preferences across music apps^{*3}</i></p> <ol style="list-style-type: none"> 1) Daily mean, SD, skew, kurtosis, min, max duration listening to music 2) Daily mean, SD, skew, kurtosis, min, max duration listening to music genres (e.g., German volksmusik, pop music, jazz, schlager) 3) Entropy in music genres in study period 4) Daily mean, SD, skew, kurtosis, min, max duration listening to German artists 5) Mean, SD, skew & kurtosis, min, max popularity of music listened to as average proportion of weekly music consumption included in the top 200 charts <p>*Artist genre extracted using the Spotify API; “German artists” recognized by 1) searching the song’s respective artist genre for “German” and, if not classified as “German”, by 2) using a language-detection algorithm on the name of the song and respective album; Popularity at the time of listening computed using the top 200 weekly</p>
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			<p>charts available in https://spotifycharts.com/regional/de/weekly/latest <i>Linguistic features of typed words</i>²</p> <ol style="list-style-type: none"> 1) LIWC2015 categories: Past orientation, Anxiety, Risk, Affiliation, 1st person plural, 3rd person plural 2) Moral foundations category: Loyalty, Purity
<i>Attribute 3: Preference for structure and routines</i>			
Duckitt & Sibley (2009)	<p>“Specifically, it was proposed that high RWA expresses the value or motivational goal of establishing and maintaining societal security, order, cohesion, and stability, which is made chronically salient for individuals by the socialized worldview belief that the social world is an inherently dangerous, unpredictable, and threatening (as opposed to safe, stable, and secure) place [...]” (p. 101)</p>	<p>+ Possession of an event calendar (Carney et al., 2008^a)</p> <p>+ Morningness (Ksiazkiewicz, 2020^a)</p> <p>+ Conscientiousness (Ekehammari, et al., 2004; Obshonka et al., 2018; Silvia et al., 2021)</p> <p>+ Need for structure (Altemeyer, 1998)</p>	<p><i>Irregularity in general activity indicators</i></p> <ol style="list-style-type: none"> 1) Irregularity in phone events 2) Irregularity in app usage 3) Irregularity in GPS movement patterns 4) Mean, SD, skew, kurtosis, min, max duration non-phone-usage intervals <p style="text-align: center;"><i>Day and nighttime activity</i></p> <ol style="list-style-type: none"> 1) Variation of time of the first event of the day on weekdays (Monday – Friday) 2) Variation of time of the last event of the day on weekdays (Monday – Thursday) 3) Variation of time of the first event on weekends (Saturdays/Sundays) 4) Variation of time of the last event on weekends (Fridays/Saturdays) 5) Irregularity of first events on weekdays (Monday – Friday)
Butler (2000)	<p>“... the closed, authoritarian personality syndrome appears to be linked to the need for routine, predictable, consistent behavior patterns.” (p. 12)</p>	<p>+ Expressions of resistance to change in tweets (Sterling et al., 2020^a).</p> <p>+Dependence on routines (Zmigrod et al., 2018)</p>	

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<p>Jost et al. (2003)</p>	<p>“...fear and aggressiveness resulting from parental punitiveness motivate individuals to seek predictability and control in their environments.” (p. 345)</p>		<p>6) Irregularity of last events on weekdays (Monday – Thursday) 7) Irregularity of first events on weekends (Saturdays/Sundays) 8) Irregularity of last events on weekends (Fridays/ Saturdays) 9) Irregularity of last events on Sundays 10) Mode hour of first event on all days 11) Mode hour of last event on all days</p> <p style="text-align: center;"><i>Planning app usage (calendar, scheduler, planning tools)¹</i></p> <p>1) App category features 2) Single app features (e.g., Google Calendar)</p> <p style="text-align: center;"><i>Linguistic features of typed words²</i></p> <p>1) LIWC2015 category: Future orientation</p>
<p><i>Attribute 4: Tendency towards aggression and emotionality</i></p>			
<p>Altemeyer (2007)</p>	<p>“[...] Authoritarian followers have a little volcano of hostility bubbling away inside them looking for a (safe, approved) way to erupt.” (p. 23)</p>	<p>+ Interest in action media (Peterson & Pang, 2006) + Self-reported interest in live sports events (Peterson & Pang, 2006)</p>	<p style="text-align: center;"><i>Use of sports media apps¹</i></p> <p>1) App category features 2) Single app features (e.g., SPORT1 App)</p> <p style="text-align: center;"><i>Use of action games (e.g., shooter games)¹</i></p> <p>1) App category features 2) Single app features (e.g., Call of Duty Mobile)</p>
<p>Altemeyer (2007)</p>	<p>“[...] One can easily find settings in which high RWAs’ aggressive inclinations comes bubbling to the surface.” (p. 27)</p>	<p>+ Preference for upbeat music (Rentfrow & Gosling, 2003)^a</p>	

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<p>Duckitt & Sibley (2010)</p> <p>Fromm (1941)</p>	<p>“Competing outgroups, particularly when the competition is over material resources and power, would generally also threaten ingroup cohesion, order, and stability, and so should also elicit RWA-based dislike.” (p. 1878)</p> <p>“Freedom, though it has brought him independence and rationality, has made him isolated and, thereby, anxious and powerless. This isolation is unbearable and the alternatives he is confronted with are either to escape from the burden of his freedom into new dependencies and submission.”</p>	<p>– Preference for energetic/rhythmic music (Rentfrow & Gosling, 2003)^a</p> <p>+ Viewing and enjoyment of reality-based crime shows (Oliver & Armstrong, 1995)</p> <p>+ Medium and heavy viewing of crime drama (Reith, 1999)</p> <p>+ Possession of sport-related décor (Carney et al., 2008)^a</p> <p>– Subjective well being (Ward et al., 2020; cf. Butler, 2000; Onraet, Van Hiel, Dhont, 2013)</p> <p>+ Expressions of negative emotions in tweets (Sterling et al., 2020)^a.</p> <p>+ Neuroticism (Obschonka et al., 2018)</p>	<p><i>Preference for aggressive and emotional music (across music apps)*³</i></p> <ol style="list-style-type: none"> 1) Mean, SD, skew, kurtosis, min, max valence of songs listened 2) Mean, SD, skew, kurtosis, min, max tempo of songs listened 3) Mean, SD, skew, kurtosis, min, max loudness of songs listened 4) Mean, SD, skew, kurtosis, min, max energy of songs listened <p>*song information extracted from Spotify API, for more details see: https://developer.spotify.com/documentation/web-api/reference/#category-tracks</p> <p><i>Linguistic features of typed words²</i></p> <ol style="list-style-type: none"> 1) Word sentiment - SentiWS emotional polarity ratings 2) LIWC2015 categories: Negative Emotions; Anxiety; Anger; Sadness; Swear words; Death; Positive Emotions 3) Emoji sentiment (Kralj Novak et al., 2015)
<p>Attribute 5: Respect for (followed) authority and hierarchy</p>			
<p>Altemeyer (1996)</p>	<p>“Authoritarians believe that proper authorities should be trusted to a great extent and deserve obedience... They</p>	<p>– Obedience to lockdown measures, both self-reported (Choma et al.,</p>	<p><i>Usage of app distributed by the government¹</i></p> <ol style="list-style-type: none"> 1) App category features

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<p>Altemeyer (2007)</p>	<p>[...] assume that officials know what is best[...] They believe, to a considerable extent, that established authorities have an inherent right to decide for themselves what they may do.” (p. 9)</p> <p>“They [Authoritarians] will tell you that people should submit to authority in virtually all circumstances. If you give them moral dilemmas (e.g. should one steal an absurdly expensive drug to save a life?) they’re more likely to say, “The law is the law and must be obeyed” than most people are.” (p. 16)</p>	<p>2021) and as measured by mobility (Gollwitzer et al., 2020^a)</p> <p>– Endorsement of social distancing in the US (Manson, 2020)</p> <p>+ Endorsement of a mandatory tracking app and other covid-preventing measures (Manson, 2020)</p> <p>– Self-damaging (e.g., drugs) and conventional (e.g., illegal parking) delinquency in adolescents (Oosterhoff et al., 2017)</p>	<p>2) Single app features (e.g., for NINA App, Corona tracing app, etc.)</p> <p><i>GPS variety change in response to lockdown measures (see distinct features for “GPS variety” in Cluster 2)</i></p> <p>1) Features listed in the GPS variety category computed for the two weeks before the “lockdown light” measures in Germany started (November 2nd).</p> <p>2) Features listed in the GPS variety category computed for the two weeks after the “lockdown light” measures in Germany started (November 2nd).</p>
<p>Altemeyer (2007)</p>	<p>“Authoritarians get a lot of their ideas about how people ought to act from their religion... [...] These churches strongly advocate a traditional family structure of father-as-head, mother as subservient to her husband and caretaker of the husband’s begotten, and kids as subservient.” (p.27)</p>	<p>+ Social Dominance Orientation (e.g., Perry et al., 2013)</p> <p>+ Use of words related to religion authority (Kugler, Jost, Noorbaloochi, 2014)</p> <p>+ Expressions of power in tweets (Sterling et al., 2020)^a.</p> <p>– Use of words related to fairness (Kugler, Jost, Noorbaloochi, 2014; Faulkner & Bliuc, 2018)</p>	<p><i>Use of religious apps¹</i></p> <p>1) App category features (overall)</p> <p>2) App category features (divided by religion)</p> <p>3) Single app features (e.g., Muslim Pro, Kirchen-App)</p> <p><i>Linguistic features of typed words²</i></p> <p>1) LIWC2015 categories: Religion, Power; Assent; Male; Female; Clout</p> <p>2) Moral foundations categories: Fairness, Authority</p>

Note. ^aAssociation found with political conservatism / partisanship rather than authoritarianism. Differences and similarities in the two constructs are elaborated in Nilsson & Jost (2020).

¹Note regarding app category and single app features: In a similar fashion to Stachl et al. (2020), we will compute features for app usage at the categorical level and the level of single-apps (see features below). App categories will only be finalized after data access given that the apps participants have on their phones cannot be known a priori. We aim to use the existing app categorization scheme from Stachl et al. (2020) and adapt it to our sample, possibly adding and re-assigning some apps with help from independent raters.

App category features:

- 1) number of apps installed at the beginning of the study
- 2) number of apps (un)installed during the study period
- 3) mean, SD, skew, kurtosis, min, max daily duration app category usage
- 4) mean, SD, skew, kurtosis, min, max daily frequency app category usage
- 5) entropy in used apps from this category in study period

Single app features:

- 1) mean, SD, skew, kurtosis, min, max daily duration app usage
- 2) mean, SD, skew, kurtosis, min, max daily frequency app usage

²Note regarding linguistic features: The Phone Study app downloaded by participants uses a modified version of the ResearchIME app (Bemmann & Buschek, 2020) for the categorisation of all typed words on participants' smartphone keyboard. In this modified version of the keylogger app, typed words are categorized according to the German version of the LIWC (Meier et al., 2020) and a German sentiment lexicon ("SentiWS", Remus et al., 2010). Further, emoji and emoticons are logged in raw form. Finally, the app goes through a German dictionary and counts the frequency of use of the words stored in the dictionary over the entire study period. We will use these word frequencies to compute the Moral Foundations dictionary [categories](#) (Graham, Haidt, & Nosek, 2009). Linguistic features will be calculated across the entire study period.

³Note regarding podcast and music listening features: The PhoneStudy app logs music and podcast listening behavior from many apps (e.g., Deezer, Google podcasts). However, our music listening features will be computed using the information available from the Spotify API. We will extract the information of music listened to on platforms other than Spotify using the heuristics elaborated in Stachl et al. (2020). All podcasts will be matched to the same list of genres obtained from the iTunes podcast taxonomy.

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