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Big Data in Radicalization Research. A Systematic Review

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Abstract: Research into extremist radicalization has been given a new momentum by digital traces of behavior, such as social media posts or publicly accessible media. Against the background that Big Data is seen as an 'epistemological revolution', this systematic literature review provides an overview of (i) the goals, data sources, and methods of trace data analysis chosen in radicalization research, as well as exemplifies some of the results of these studies, and (ii) analyzes the similarities and differences with traditional studies such as questionnaires or experimental studies. This overview is based on 63 studies, of which, however, only a small proportion (k = 18) used digital behavioral trace data, while the majority consist of traditional approaches (k = 52). The results show that trace data studies were largely aimed at identifying individuals with radical attitudes and predicting the development of radical views. Overall, behavioral trace data open up previously untapped potential for the analysis of personality profiles and the investigation of dynamic social interactions of those susceptible to extremist recruitment.

Keywords: online radicalization, systematic review, digital trace data, Big Data

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The research of digital traces of behavior, e.g. postings on social media sites, click-behavior on websites or networking data of persons, has gained momentum in recent years. Such data offer an understanding of phenomena as they occur in real time in their natural environment (Landers et al., 2016). Thus, the collection of behavioral trace data enables the direct observation of behavior (e.g. acceptance of group norms, postings, or networking with people) and its determinants (e.g. personality traits) in a social context (e.g. in social networks on social media platforms) - with a low risk of bias, which is often present in traditional methods such as questionnaire data (Marres, 2015). Examples are the collection of data from online-forums, instant messaging and social networks such as Facebook or Twitter (Kosinski et al., 2016).

For research on radicalization, access to digital behavioral trace data provides not only insights into the behavior of hard-to-reach individuals in situ (e.g. people with extremist attitudes), but also the observation of precisely those social environments in which radicalization takes place and by which it is promoted (Ebner, 2019). For example, the online-milieu around platforms such as Gab, 4chan, 8chan, or Discord has been identified as a significant site of radicalization processes after the Christchurch assassination or the leak of the right-wing extremist forum ‘Iron March’ (Munn, 2019). The fact that these milieus are difficult to regulate, are only partially visible from the outside and operate in the guise of anonymity, seems to promote escalating dynamics and raises questions about the conditions under which extremism-promoting beliefs, attitudes and dispositions arise (Munn, 2019; Pelzer, 2018).

Against the background of the value of digital behavioral trace data, the question therefore arises as to the relative importance of research with behavioral trace data. In particular, this study has the following purposes: Firstly, a systematic overview will be used to shed light on the research goals, data sources, and methodological approaches that are the focus of current

research with behavioral trace data and the results of this research. Secondly, similarities and differences of such studies with 'traditional' approaches (questionnaire studies and experimental studies) will be highlighted in order to illustrate how the different research approaches complement each other.

Background: Radicalization and Digital Behavioral Trace Data

While research into radicalization tendencies and their determinants has a decades-long tradition, the relevance of this research has increased in recent years (Schuurmann, 2018). Using trace data in this area is fruitful not only because of the unobtrusive collection of data (as opposed to questionnaires), but also because it offers the possibility of analyzing radicalization processes on social media platforms and thus at the very place where they take place. In this context, Ebner (2019) speaks of such platforms as "radicalization machines" (p. 10), which enable radicalization processes to the present extent.

In addition to the data that can be extracted by social media platforms, another source of digital behavioral trace data are open-source data (e.g. consisting of data sources such as PIRUS or ECDB). These sources provide information such as media reports, event data, and material from extremists, government documents, trial records and press releases from the American-speaking world. These sources provide anonymized background information on individuals who have links to extremist organizations or who have themselves demonstrated ideologically motivated criminal activities. These background characteristics can be demographic or biographical features, or information on mental health, ideological background, and time period of radicalization, group dynamics or recruitment mechanisms. This possibility of viewing offline-characteristics is much more limited for social media approaches. Only political attitudes of the users (cf. Fernandez, 2018) as well as geographical localization and possibly related general sociographic data (cf. Mitts, 2019) can be extracted or inferred from statements.

Beyond the scientific relevance of digital behavioral trace data for research on radicalization, the methodological innovations that have emerged in recent years, particularly with regard to the extraction of online data and quantitative text analysis ('text mining', see Kern et al., 2016), offer valuable opportunities for psychologists to conduct research with such data. Text data can be extracted in large quantities and analyzed quantitatively and statistically; the results of such analyses include the categorization of contents into predetermined or exploratively identified thematic categories, or the measurement of psychologically relevant dimensions such as attitudes or even personality traits. As described at the beginning, there is a lack of a systematic overview of the use of such data sources and research designs, their questions and the comparison with traditional designs. In the following, the systematics of the literature search will be described, followed by a presentation of descriptive characteristics of all identified studies. Finally, a systematic analysis of the behavioral trace data studies will be undertaken.

Method

The search for relevant research was based on the PRISMA guidelines (Moher et al., 2009), which divide the search process into the steps ‘identification of publications’, ‘screening’, ‘proficiency testing’ and ‘inclusion’ (for a full specification of the selection criteria, the search strategy and included studies, see PsychArchives-OD). Selection criteria were (i) the application of research designs with possibilities for quantitative analysis (digital behavioral trace data, self-reports or experiments); (ii) focus on the following forms of radicalization: political extremism (e.g. right or left extremism), religious fundamentalism (e.g. Islamism), nationalist/separatist extremism, ‘single-issue’ extremism (e.g. environmental protection or abortion) or ideologically independent extremism; (iii) research on radicalization determinants at the micro-level (e.g.

psychological predispositions), meso-level (exposure to radical social environments) or macro-level (structural conditions, such as housing segregation or unemployment rates).

The selection of studies included those that focused on violent manifestations of radicalization as well as its determinants. These were, for example, violent convictions and attitudes of persons or the willingness to use violence. In contrast, studies that investigated broader attitudes or dispositions (e.g. right-wing authoritarianism or social dominance) were excluded. The search was carried out for the period 2005-2019 - especially since, beginning with the second wave of terrorism research and the emergence of new methods, the phenomenon of radicalization increasingly came into the focus of research (Pape, 2009). The search was conducted using five databases and six other resources (e.g. PubPsych) (see OD 2). Finally, only studies that focused on populations in the USA and Europe were included.

The information extracted from the articles falls into four categories: (i) survey mode (digital behavioral trace data, self-reports, experiments), (ii) analyzed behavioral determinants (psychological dispositions, demographic characteristics, exposure to radical contexts, emergence of radical framework conditions), (iii) results of radicalization processes (violent behavior, readiness for violent behavior, attitudes towards extremism, type of extremism), (iv) population (e.g. geographical context, sample size, age distribution). The initial screening of the publications was carried out by three independent coders. Selected full texts were checked for suitability by the first author (see OD 1).

Results

Study Description

Of the 6,602 studies resulting from the database search, only 63 met the inclusion criteria. This is due to a very high proportion of qualitative or purely conceptual papers. As expected, the majority of the studies were studies with traditional designs - i.e. based on self-reports (k = 38) and experiments (k = 14). A small part was related to the collection of trace data (k = 18). This group could in turn be differentiated into studies that collected behavioral trace data on social media (k = 8) and those that were based on open-source secondary data (k = 10).

Regardless of the design, about 27 percent of all studies (k = 17) dealt with Islamist fundamentalist extremism. The remainder of the studies focused on ideologically independent extremism (k = 12), right-wing extremism (k = 6), left-wing extremism (k = 1), nationalist/separatist forms (k = 1) and mixed forms (k = 13). A total of 101 samples were examined - about 30 percent of these (k = 31) consisted of adults from the general population, while the rest were students/pupils (k = 29), Muslim sub-populations (k = 9) or other special sub-populations such as offenders (k = 10) or activists (k = 6).

Aims, data sources and methods of behavioral analysis

Table 1 summarizes the results of the overview of studies based on digital behavioral trace data. In terms of interest, these studies can be categorized into the following groups (cf. OD 3): (a) analysis of the role of experiences of discrimination and deprivation in the process of radicalization (k = 3), (b) identification of radicals and prediction of their development (k = 6), (c) characterization of individuals with regard to psychological predispositions (k = 3), or (d) comparison of different groups (e.g. of ‘lone wolves’, gangs, converts, or by type of offence) (k = 6).

As far as the data source is concerned, about half of the trace data studies used open-source data (k = 10; 55.6%) and the other half used social media data (k = 8; 44.4%). The latter referred exclusively to the platform 'Twitter'. As can be seen in Table 1, open-source-based studies mostly analyzed information on criminally convicted persons. In terms of content, they mainly referred to Islamist radicalization and its determinants. Such determinants were, for example, marital status or the existence of intact relationships, mental health, trauma, or post-traumatic stress disorders (LaFree et al., 2018). Exemplary for the characterization of personal psychological predispositions is the work of Jasko et al. (2016) who, based on the PIRUS (Profiles of Individual Radicalization in the United States) data, used a sample of almost 1,500 political extremists. The most important outcome variable was whether the illegal act committed was violent (e.g. bombing) or non-violent (e.g. illegal protest). It was found that individuals more often used violence to pursue their ideological goals when they had experienced failure situations at work and when they had problems in social relationships. These results provide evidence of the connection between the motivation to feel significant and the use of political violence.

Another example of an open-source-based study is the study by Pyrooz et al. (2017), which used a combination of the PIRUS database and the National Longitudinal Survey of Youth (NLSY97) database to compare two types of groups - criminal but non-political gangs ('street gangs') and extremist groups. The aim of the study was to identify differences between the groups in terms of length of membership and demographic, family and socioeconomic characteristics. In addition, the authors investigated whether members of extremist groups had a history as gang members. The result was that only six percent of extremist persons had previously been in a street gang. With regard to group membership, only marital status (gang members were less often married and less often parents), ethnicity (whites were more likely to be in extremist groups, non-white minorities more likely to be in street gangs) were more

predictable. The role of gang membership depended on the religious community in question: while people with a Christian background were far more likely to belong to a street gang, the opposite was true for members of all other religious communities. Finally, members of extremist groups show an ostensibly higher level of education than members of street gangs.

In contrast to the open-source-based studies, studies focused on social media either analyzed postings using ‘Text mining’ or applied networking approaches to investigate social relationships between people. The studies based on the postings pursued the goal of classifying postings, e.g. in terms of the extent to which they reflected the perception of discrimination (Lara-Cabrera, Gonzalez-Pardo & Camacho, 2019), signaled support for extremist groups (Fernandez, Asif & Alani, 2018), or showed signs of incipient radicalization. The latter was operationalized, for example, through the first use of ideological rhetoric or the dissemination of fundamentalist content from known accounts, by the individual (Rowe & Saif, 2016).

To categorize the postings, linguistic features of the statements were used. These were stylistic features (e.g. the omission of sentence parts and the capitalization of whole text parts as markers for introversion and frustration), content-related terms (e.g. hashtags, ideological or political terms such as the naming of war zones) and terms which, although not related to content, nevertheless prove to be predictive (e.g. emotion words such as 'ugly' or 'nasty' which reflect affective processes) (cf. Alizadeh et al., 2019).

In addition to the text analysis of the postings, some studies aimed to analyze the networks of individuals, e.g. what role the networking density of participating individuals plays (Reganti et al., 2017), or what predictions metadata (e.g. existence of an account suspension or geographical data of individuals) provide for radicalization. However, these were then only occasionally combined with 'open-source data' such as regional election results or unemployment rates in order to estimate the spread of political attitudes or structural disadvantage in the

immediate vicinity of the users (cf. Bail, Merhout & Ding, 2018; Mitts, 2019). For example, Mitts (2019) examined whether membership of an extremist group was influenced by experiencing anti-Muslim hostilities. In the study, postings from jihadist Twitter accounts were extracted and then classified according to various dimensions of ISIS-sympathy and persons were assigned to geographical locations. It was shown that people who were located in regions where anti-Muslim parties are strongly represented were more likely to show signs of radicalization than others in less hostile locations (Mitts, 2019). It must be noted, however, that although regional unemployment and the occurrence of terrorist attacks have been statistically controlled, this is only weak evidence of the assumed effect.

Similarities and differences to traditional studies

While trace data studies provide unique results due to these special data sources and forms of analysis, a comparison with 'traditional' studies (experimental studies or studies based on self-reports) also shows some overlaps. Experimental studies (k = 4) and questionnaire studies (k = 9) focused on the impact of experiences of discrimination and deprivation. For example, Bäck et al. (2018) investigated in their laboratory experiment the effect of social exclusion on the acceptance of the political attitudes of a radical group. The basis of the experiment was the 'cyberball paradigm' in which participants play an online-game with (allegedly) other people. In the study with 71 students, half of the people in the exclusion condition suddenly stopped being involved in the game. When the persons received a message from a fictitious member of a radical left-wing group after the end of the game, it became apparent that those persons who were particularly sensitive to rejection had an increased tendency to adapt their attitudes to those of the radical group.

Furthermore, similarities between traditional studies and trace data studies focusing on the influence of peer groups on the imitation or reinforcement of extreme political attitudes or

behavior were found. Dahl (2017) used social network analysis to investigate how peers affect the attitudes and values (including advocacy of political violence) of young people in Sweden and whether these attitudes and norms influence their choice of friends. It was found that peers influence attitudes towards migrants, but the same effect does not apply to general political (universalistic) value orientations. In contrast, a universalistic peer network showed a reducing effect on support for political violence.

The most obvious difference between trace data studies and traditional studies is the form of data collection. Here, behavioral trace data have the enormous advantage of extracting behavioral data not affected by self-perception and desirability tendencies and this also in a far larger number of cases than in traditional studies. In contrast, trace data are less helpful when it comes to measuring psychological characteristics such as personality traits, where aspects such as reliability or validity are often unclear or, in the worst case, insufficient. And even if, for example, linguistic features of a text prove to be of predictive use, it is often unclear which construct was actually measured here. In this context, traditional questionnaires are irreplaceable despite their weaknesses. For future research, forms of triangulation would be helpful, in which both behavioral data on trace data are collected, enriched by traditional measurement with questionnaires. Similarly, field or natural experiments in combination with both data sources should make it possible to investigate the impact of interventions or naturally occurring events (e.g. changes in legislation) on radicalization processes.

Discussion

Considering the importance of digital trace data - especially extracted from social media platforms and open-source sources - this overview of the field of radicalization research shows that not only is the number of studies on this topic limited (cf. Schuurman, 2018), but also the

range of analysed platforms: Although social media platforms essentially represent the social spaces in which radicalization processes take place (Ebner, 2019), the results show that only a few studies analyze social media data. The sole focus on Twitter in this context is already criticized by Parekh et al. (2018). Lesser-known platforms such as 4chan have so far been insufficiently considered in terms of their relevance and reach for the radicalization process (Schmid & Forest, 2018). In view of the intensive linkage and interaction of social networks (cf. Johnson et al., 2019), a holistic view across platforms is lacking, as is an answer to the question of whether determinants and conducive environments that have been analyzed on one platform can be generalized to others. This is of relevance, especially since predominantly verbal behavior is observable on Twitter, while other platforms are more strongly characterized by visual elements (e.g. so-called ‘memes’ - i.e., rapidly spreading images with pointed verbal expressions) (Munn, 2019). Other platforms, such as the ‘"Iron March Forum’, are strongly characterized by anonymity, irony and acronyms and cannot be quantified with classical text mining approaches. The latter illustrate new challenges in the evaluation and transferability of previous theoretical assumptions to these milieus.

While questionnaire studies are often criticized for the risk of bias due to measurement errors and desirability tendencies, digital behavioral trace data analysis also face problems: While demographic characteristics can easily be extracted, the extraction of context data (e.g. number of retweets, number of friends) and user-generated content (e.g. text content, likes of other users' statements, self-reported individual differences) must be done with respect to the target construct, taking into account the context in which the behavioral traces were created when interpreting them (cf. Landers et al., 2016). In order for digital behavioral trace data analyses to acquire theoretical relevance, it is essential to integrate them into a ‘data or measurement theory’ that conceptualizes behavior as a product of the interaction between person and situation (ibid.).

Finally, digital behavioral trace data analyses offer an understanding of radicalization, which is caused by determinants that partly stem from the biographical course of development (e.g. experienced deprivation). While this is a clear causal focus, existing studies are based almost exclusively on cross-sectional designs. With the newly emerging possibilities offered by digital behavioral trace data, the focus should be on the integration of traditional approaches and new technologies in order to map the process character. As an example, approaches such as online field experiments on the dissemination of emotional states in social networks, as already implemented by Kramer et al. (2014), could provide new insights into the milieu and have heuristic significance and explanatory value.

Table 1

Determinants and frameworks in digital behavioral trace data analyses

Determinants	Islamism		Polit. & Islam.		Non-ideol.	RWE/+
	SM	OS	SM	OS	OS	OS
Psychological Dispositions						
Psychopathology/ mental health	0	0	0	1	2	0
Personality profiles	2	0	1	0	1	0
Trauma, injustice and alienation	1	1	0	1	0	0
Personal status and rewards	1	0	0	0	0	0
Disinhibition of moral inhibitions	0	0	0	0	0	0
Self-control	0	0	0	0	1	0
(Institutional) trust	1	0	1	0	0	0
Risk taking	1	0	0	0	0	1
Intolerance of ambiguity	0	0	0	0	0	0
Consumption (drugs, alcohol)	0	0	0	0	2	0
Demographic Characteristics						
Work history	0	0	0	3	1	0
Educational background	1	1	0	1	1	1
Family status	0	0	0	2	0	1
Military experience	0	0	0	3	0	0
Social relations (intimate, peers, family)	0	0	0	1	1	1
School or work success	0	0	0	2	1	0
Crime-related Background Characteristics						
Criminal record	0	0	0	1	1	1
Parental violence and abuse	0	0	0	1	1	0
Further Individual Features						
Gender	2	1	0	3	0	0
Age	2	1	0	2	0	1
Religion	0	0	0	1	1	0
Ethnicity	0	0	0	2	1	0
Socioeconomic status	0	0	0	0	0	0
Political orientation	0	0	0	0	0	0
Exposure to Radical Contexts						
Social network: radical peers/ family members	2	0	1	1	1	2
Gang affiliation	0	0	0	1	1	1
Emergence of Radical Environments						
Housing segregation	0	0	0	0	0	1
Sociodemographic (share of poverty, unemployment, religion)	1	0	0	0	0	1
Media	2	0	0	0	1	1
(Foreign) Politics	3	0	0	0	0	1
Group-related Grievances						
Relative deprivation (marginalization)	1	1	0	0	0	0

Note. Included are 18 publications. The prevalence of radicalization determinants, from social media (SM) and open source (OS) behavioral data is presented depending on forms of extremism (Islamism, political extremism in combination with Islamism ("Polit. & Islam."), non-ideological extremism ("non-ideol."), and right-wing extremism in combination with single-issue, or Islamism ("Right/+").

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Note. (*) indicates studies included in the review.

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Open Data

OD 1. (S1_PRISMA.pdf): PRISMA Flow Chart

OD 2. (S2_ Search.pdf): Search strategy and data bases

OD 3. (S3_Included_studies.pdf): References of included studies