Article

The degree of heterogeneity of news consumption in Germany—Descriptive statistics and relations with individual differences in personality, ideological attitudes, and voting intentions

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Abstract

This study aimed to examine the degree of homogeneity versus heterogeneity of individuals' political information environments across offline and online media types and relations with sociodemographic variables, personality, and political attitudes. In two online surveys, German participants (sample 1: $N = 686$; sample 2: $N = 702$) provided information on sociodemographic variables, consumption of political news, and voting intentions, and completed the Big Five Inventory and Right-Wing Authoritarianism (RWA) and Social Dominance Orientation (SDO) scales. Results revealed that absolutely homogeneous political news consumption was evident for a small proportion of individuals (2.04% and 0.43%). Openness (positively) and Agreeableness (negatively) exhibited significant associations with the degree of heterogeneity of political information environments across samples. No consistent patterns of relations with either the ideological attitudes of RWA and SDO or voting intentions were observed. The findings shed light on the existence of absolutely homogeneous political information environments and "who" might be prone to a more homogeneous versus more heterogeneous information environment.

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Introduction

So-called filter bubbles and echo chambers generate much discussion in the mass media and scientific literature. In relation to political views, some experts fear that an environment containing homogeneous information can reduce the consumption of alternative viewpoints, contribute to the polarization of an individual's opinions, and, more broadly, constitute a threat to democracy at large (Bozdag and van den Hoven, 2015; Sunstein, 2004). Other experts, however, disagree and question the existence and/or negative effects of homogeneous information environments (e.g. Noor, 2017). In line with this disagreement, research in this area has been inconclusive. The present study aimed to contribute empirical data to the ongoing discussions by investigating (1) the degree of homogeneity versus heterogeneity of political news consumption by individuals across various offline and online media types, using a dimensional approach, (2) who is more or less prone to consume more homogeneous versus more heterogeneous political news, and (3) whether the degree of homogeneity versus heterogeneity of one's political news consumption is associated with ideological attitudes and/or voting intentions. Given the background of the replication crisis in psychology, and in order to produce robust and reliable findings (see the problems shown in the work of the Open Science Collaboration, 2015), all analyses were replicated across two independent population-based samples.

Homogeneous information environments

Terms like echo chamber (Sunstein, 2004, 2007), information cocoon (Sunstein, 2006), and filter bubble (Pariser, 2011) were coined many years ago. These concepts are defined somewhat differently, and varying mechanisms contributing to their emergence have been discussed (see Supplementary Material). Nevertheless, all of the aforementioned concepts have one characteristic in common: They highlight the notion of a homogeneous information environment, in which individuals are exclusively provided with information aligned with their pre-existing attitudes. In line with this, the present study uses the term "absolutely homogeneous information environment" to describe an environment in which one is exclusively presented with homogeneous *and* attitude-consistent information.

Digital services such as social media are often singled out for criticism for unduly contributing to homogeneous information environments (Pariser, 2011; Sunstein, 2007). This is most likely due to the fact that social media platforms interactively combine the effects of algorithmic, self-selected, and social filtering (Flaxman et al., 2016; Messing and Westwood, 2012). However, there are opposing expert views that value the possibilities for information presentation and consumption via online services (Noor, 2017). While the results of some studies indicate that filtering of information on social media is associated with some degree of homogeneity of information (An et al., 2013; Bakshy et al., 2015; Flaxman et al., 2016), results also suggest that most individuals are still

exposed to counter-attitudinal information on social media and online news platforms (Bakshy et al., 2015; Flaxman et al., 2016; Gentzkow and Shapiro, 2011; Min and Wohn, 2020; Newman et al., 2017; Vaccari et al., 2016). It is, therefore, debatable whether absolutely homogeneous information environments, the concepts underlying terms such as echo chamber and filter bubble, actually exist in practice.

In addition, one needs to consider that individuals can also consume information offline where algorithmic filtering is impossible. Neglecting the influence of offline information consumption might bias the estimated degree of homogeneity of an individual's overall information environment. On that basis, a focus on online news media—or social media specifically—seems insufficient.

Therefore, to investigate information environments, the present study adopts a dimensional approach, where absolute homogeneity and heterogeneity represent extremes of one dimension. In addition, the present study aims to broaden the focus often found in previous work, which has focused mainly on online news media, or social media specifically, by also considering offline media types when investigating information environments of individuals.

Sociodemographic variables, personality, and degree of homogeneity versus heterogeneity of one's information environment

Aside from investigating the potential existence of absolutely homogeneous information environments (especially across online and offline media types), another important topic in this area is the discussion of the putative effects of individual differences. Each individual can—at least to a certain degree—influence the degree of heterogeneity of his/her information environment. As an example, each individual can decide on whether to consume news via sources suspected of filtering information individually for each user (e.g. social media) or via sources that do not filter information on an individual level (e.g. newspapers or radio shows). Moreover, individuals can decide on the number of pro- and anti-attitudinal news they consume. At this point, however, it is largely unclear how individual differences in variables like sociodemographics and personality traits are associated with the degree of heterogeneity of an individual's information environment.

Sociodemographic variables. Previous research has revealed associations between time spent with/regularity of news consumption and age (positively), gender (higher in men), and educational degree (positively) (Benesch, 2012). Moreover, links between age (positively) and gender differences (higher in men) with the number of news sources consumed have been reported (Sindermann et al., 2020); but see nonsignificant results for both sociodemographic variables in Sindermann et al. (2021). Thus, higher age, male gender, and higher educational degrees might be associated with a higher degree of heterogeneity of an individual's information environment.

Personality. Individual differences can be studied based on the Five-Factor Model of Personality, which suggests that personality can be described based on five broad domains (Fiske, 1949; Tupes and Christal, 1992). These domains are frequently subsumed under the term *Big Five* and labeled Openness (to Experience), Conscientiousness, Extraversion, Agreeableness, and Neuroticism (Costa and McCrae, 1992b; Goldberg, 1990; John and

Srivastava, 1999). High scores on Openness describe individuals who are more open to novel ideas, arts, cultures, and so on (Rammstedt and Danner, 2017), and Openness has been found to positively relate to the number of news sources consumed (Sindermann et al., 2020, 2021). Further to this, one study using behavioral data reported that Openness was, among other things, positively associated with the diversity of pages liked on Facebook with regard to political ideologies and personal values (Matz, 2021). These findings support the intellectual stimulation hypothesis stating that Openness is positively related to cross-cutting exposure (Kim and Kim, 2018). It should be noted, though, that contradictory results exist (Bessi, 2016). In summary, however, it can be expected that Openness from the Big Five is positively associated with the degree of heterogeneity of an individual's information environment.

Ideological and political attitudes and degree of homogeneity versus heterogeneity of one's information environment

A more homogeneous information environment might be especially problematic in the context of politics. Experts claim that an increasingly homogeneous information environment might contribute to the polarization of opinions. Some even suggest that extremely homogeneous political information environments may be a threat to democracy itself (Bozdag and van den Hoven, 2015; Sunstein, 2004).

Ideological attitudes. In line with these claims, the ideological attitudes Right-Wing Authoritarianism (RWA) and Social Dominance Orientation (SDO) of the Dual-Process Motivational Model (e.g. Duckitt and Sibley, 2009, 2010) are of special interest. RWA consists of the facets conventionalism, authoritarian aggression, and authoritarian submission (Beierlein et al., 2014). High scores on SDO describe individuals who favor hierarchies in the social structure over equality (Pratto et al., 1994). Both RWA and SDO seem to be strongly positively related to closed-mindedness (Berggren et al., 2019). Moreover, results from a study by Sindermann et al. (2020) showed that RWA was negatively associated with the number of news sources consumed; SDO was not investigated in that study. Another study by Sindermann et al. (2021) found a small but significant negative association for RWA, and a non-significant association (close to zero) for SDO, with the number of news sources consumed. Finally, RWA and SDO have been negatively associated with Openness before (Butler, 2000; Sindermann et al., 2020, 2021). These results suggest that RWA and SDO are negatively related to the degree of heterogeneity of an individual's information environment.

Political attitudes. Previous findings from empirical studies investigating associations between the heterogeneity of participants' information environments on social media and associations with (extreme) political attitudes reveal inconsistent results (Bail et al., 2018; Barberá, 2015; Heatherly et al., 2017; Lee et al., 2014; Levy, 2021). Furthermore, many of these studies deal with homogeneity versus heterogeneity of information environments on social media, sometimes on one platform, specifically. Individuals can, however, use many more news sources aside from social media, potentially attenuating the effects of associations between homogeneity of (political) information consumed via on social media and

political attitudes. Accordingly, findings on whether or not a lower degree of heterogeneity of one's (political) information environment more broadly (not focusing specifically on social media) is associated with polarization and/or more extreme political attitudes remain inconclusive. It clearly seems important then to investigate the degree of heterogeneity of political information environments and associations with political attitudes across different news sources. In a related area, a study from Germany found that a group of individuals who stated they would not vote if general elections were held the following Sunday showed the lowest number of different news sources consumed across offline and online media types. This group was closely followed by the groups of individuals who had the intention of voting for the Alternative für Deutschland (AfD), which represents a populist right-wing party (Bundeszentrale für politische Bildung, 2017; Schleunes et al., 2020; Volkens et al., 2020) or for "other" smaller parties (Sindermann et al., 2020). Potential voters of DIE LINKE (the left-wing German party), which can be deemed the most extreme left of the major German parties (Volkens et al., 2020), reported the highest number of different news sources consumed (Sindermann et al., 2020). This indicates that the lowest heterogeneity of political information environments is linked to individuals intending to abstain from voting, or to vote for the AfD or for "other" smaller parties; although it must be noted that the sample of the previous study was not representative of the general German population and that heterogeneity in news consumption was not directly assessed.

Summary and aims of the present study

In summary, there is an ongoing discussion on whether and to what extent homogeneous information environments exist. The present study aimed to contribute to this discussion by providing empirical data on the information environments of individuals in relation to political news by applying a dimensional approach. In comparison to many previous studies, we took into account various online and offline media types.

The present study also aimed to examine individual differences in sociodemographic variables and personality in association with the degree of heterogeneity of one's political information environment. We expected age (positively), gender (higher in men), educational level (positively), and Openness (positively) to be associated with a higher degree of heterogeneity of one's political information environment.

Finally, we aimed to investigate associations between the degree of heterogeneity of political information environments with ideological and political attitudes. RWA and SDO were expected to be negatively associated with the degree of heterogeneity of one's political information environment. We also expected lower heterogeneity of political information environments for the groups of individuals indicating they would not vote, vote for the AfD, or for "other" smaller parties.

Method

Procedure

The present study, including sample size calculations (see also Supplementary Material), procedure, measures, and statistical analyses, was preregistered. Data and the data analysis

script are available at the Open Science Framework (https://osf.io/dr2pq/). Two independent samples were recruited for the present research using two online surveys. The investigation of effects across different samples is of great importance, given the replication crisis in psychology (Roediger, 2012). In addition, building predictive models in one sample and testing them in a separate sample helps to identify and overcome the problem of results being applicable only to specific samples.

Both studies were implemented in the SurveyCoder platform (Kannen, 2018, 2020) and the same inclusion criteria were applied: Anyone from Germany who was allowed to vote in the general German elections in 2021 and who was at least 18 years old was eligible to participate, provided they gave their informed electronic consent prior to participation. The eligibility criteria were checked via self-report at the beginning of the surveys.

The first sample was recruited by the respondi AG (https://www.respondi.com/) by advertising the online survey in their panel sample, which is also used for market research. Due to the large participant pool, the respondi AG can recruit a diverse sample with regard to distributions of gender, age, and location (i.e. federal state). Participants from sample 1 were incentivized in accordance with the regulations of the respondi AG. Data collection was implemented at the end of February 2021.

The online survey for the second sample was advertised via various offline (printed press, etc.) and online (social media, online magazines, etc.) methods and was part of a larger research project. Each time the first author gave an interview on related topics the link to the study was presented to the audience. Twitter ads were used to distribute information and the link to the study, as well. Students who wrote their theses on this project also advertised the study. Finally, several "influencers" on Instagram and YouTube shared the link to the online survey and asked their followers to participate. These "influencers" were individuals providing their followers with general knowledge, knowledge of the natural sciences and psychology, inspirational motivation, and coaching advice. This sample is a convenience sample. As an incentive, participants from sample 2 received automated and anonymous feedback on their scores for some of the questionnaires (e.g. Big Five Inventory). Data for this survey were collected between December 2020 and February 2021.

The online surveys were approved by the local ethics committee of Ulm University.

Samples

After data cleaning (see Supplementary Material), a final sample size of $N=686$ individuals remained in sample 1: $n=385$ men, $n=301$ women; M(age)$=56.59$ years, SD(age)$=15.55$. Most individuals stated secondary school leaving certificate (German: Mittlere Reife; $n=264$) or university (including university of applied sciences) degree ($n=206$) as their highest educational degree. There were participants from each federal state in Germany in this sample.

After data cleaning (see Supplementary Material), a final sample size of $N=702$ ($n=459$ men, n$=243$ women; M(age)$=27.03$ years, SD(age)$=10.60$) individuals remained in sample 2 for final analyses. Most individuals stated A-level/high school diploma (German: Abitur; $n=309$), university (including university of applied sciences) degree ($n=220$), or secondary school leaving certificate (German: Mittlere Reife;

$n = 114$) as their highest educational degree. There were participants from each federal state in Germany in this sample.

A descriptive comparison of the two samples with German census data in relation to some key variables is presented in the Supplementary Material. None of the samples is completely representative of the general German population.

Measures

The same measures were used in both surveys to recruit sample 1 and sample 2. Details on internal consistencies are presented in the Supplementary Material.

Personality. The Big Five personality traits were assessed by using the German version of the Big Five Inventory (BFI) (John et al., 1991; Rammstedt and Danner, 2017). This questionnaire consists of 44 items. Actually, the German version of the BFI comprises an additional 45th item. This item, however, was not considered in the present analyses for closer comparability with studies applying the questionnaire in other languages. Each item was answered on a 5-point rating scale ranging from 1 = "very inapplicable" to 5 = "very applicable."

Ideological attitudes. RWA was assessed using the Short Scale on Authoritarianism (KSA-3; abbreviation based on the German name of the scale) (Beierlein et al., 2014). The scale consists of nine items answered on a 5-point rating scale ranging from 1 = "strongly disagree" to 5 = "strongly agree."

SDO was assessed by applying a German version (Six, Wolfradt and Zick, 2001, as cited in Mortal, 2011 and revised by Sindermann et al., 2021) of the Social Dominance Orientation scale by Pratto et al. (1994). The questionnaire consists of 16 items, answered on a 7-point rating scale ranging from 1 = "very negative" to 7 = "very positive."

Current voting intentions. Voting intentions were assessed using one question asking participants which party they would vote for if general German elections were held the following Sunday. Response options were: DIE LINKE, SPD, Bündnis 90/Die Grünen, FDP, CDU/CSU, AfD (parties ordered from left to right according to Volkens et al. (2020); the first three are left-of-center and the latter three are right-of-center parties), others, and "I would not vote."

Degree of homogeneity versus heterogeneity of political news consumption. A detailed description of the theoretical underpinnings of the measure assessing the degree of (homogeneity versus) heterogeneity of political news consumption is presented in the Supplementary Material.

The following items assessing the participants' news consumption were used:

1. Participants were initially asked whether they used each of the following eight media types to become informed about political news (1 = "yes," 0 = "no"): (1) TV, (2) print media, (3) radio, (4) online news websites, (5) smartphone news applications, (6) news aggregators, (7) podcasts, and (8) news feeds of social media platforms.

2. Next, for each media type used, participants were further asked about how many different sources they consumed political news on during the past 6 months via the respective media type (e.g. number of different TV news shows).
3. Finally, for each media type used, participants were asked how often they were confronted with news contradicting their pre-existing attitudes during the past 6 months when consuming political news via the respective media type on an 11-point scale from $0.00 =$ "never" to $1.00 =$ "(almost) always" (in steps of 0.10).

As described in the preregistration, the responses to the second variable on different news sources per media type were winsorized: If the score of a person was identified as a univariate outlier for the respective variable, the score was exchanged by the closest score which was not identified as an outlier, according to the formula by Tukey (1977).

Using the variables described above, we were able to investigate the degree of heterogeneity across media types by summing scores derived from all media types. The homogeneity versus heterogeneity of political news consumption score (HoHe score) was calculated as follows:

$$
\begin{aligned}
\text{HoHe score} = &\left[\left(\text{tv\_yes}(1/0) \times \text{tv\_nr} \right) \times \left(\text{tv\_contra} \right) \right] + \\
&\left[\left(\text{print\_yes}(1/0) \times \text{print\_nr} \right) \times \left(\text{print\_contra} \right) \right] + \\
&\left[\left(\text{radio\_yes}(1/0) \times \text{radio\_nr} \right) \times \left(\text{radio\_contra} \right) \right] + \\
&\left[\begin{array}{l} \left(\text{onlinenewswebsites\_yes}(1/0) \times \text{onlinenewswebsites\_nr} \right) \\ \times \left(\text{onlinenewswebsites\_contra} \right) \end{array} \right] + \\
&\left[\left(\text{apps\_yes}(1/0) \times \text{apps\_nr} \right) \times \left(\text{apps\_contra} \right) \right] + \\
&\left[\left(\text{aggregators\_yes}(1/0) \times \text{aggregators\_nr} \right) \times \left(\text{aggregators\_contra} \right) \right] + \\
&\left[\left(\text{podcasts\_yes}(1/0) \times \text{podcasts\_nr} \right) \times \left(\text{podcasts\_contra} \right) \right] + \\
&\left[\left(\text{newsfeed\_yes}(1/0) \times \text{newsfeed\_nr} \right) \times \left(\text{newsfeed\_contra} \right) \right]
\end{aligned}
$$

By applying this formula, we made sure that (1) media types that were not used by an individual did not contribute to the HoHe score (also, all media types used by an individual were considered), (2) the variety of news sources within a media type was taken into account and increased the HoHe score, (3) the number of sources used via each media type was weighted with the frequency of being confronted with counter-attitudinal news on this media type, and (4) the result of the multiplication of sources within one media type by frequency of being confronted with counter-attitudinal news within this media type was weighted equally across media types.

Higher scores indicate higher heterogeneity in one's political news consumption. Importantly, the HoHe score can be interpreted relatively but cannot be interpreted in absolute terms: It is difficult to precisely specify what a score of 5 means because different patterns of responses to the items can lead to a score of 5, but a score of 10 versus 5 can be interpreted.

Statistical analyses

Analyses were implemented in the statistical Software R 3.6.3 (R Core Team, 2018) and RStudio 1.3.959 (RStudio Team, 2020). Packages used are presented in the Supplementary Material and in the R-script uploaded at the Open Science Framework.

An approximate normal distribution was assumed for all variables except the HoHe score based on the rule of thumb by Miles and Shevlin (2001), and taking into account the large sample size. Statistical analyses were conducted accordingly.

Descriptive statistics for all variables of main interest were calculated in both samples separately. Results of statistical comparisons of the samples across the variables of main interest are presented in the Supplementary Material.

Associations with age, gender, and education are also presented in the Supplementary Material. These analyses led to the decision to include the three sociodemographic variables in the regression models and linear discriminant analyses (see subsequently).

Zero-order Spearman correlations were implemented in each sample to investigate associations of the HoHe score with other continuous study variables of main interest and to select variables to include in the regression models.

Subsequently, regression models were calculated in each sample. The root-square-transformed HoHe score (to more closely align with prerequisites for linear regression models) was predicted by (i) sociodemographic variables, (ii) variables for which hypotheses were formulated, and which where significantly correlated with the HoHe score in at least one of the samples, and (iii) variables that correlated significantly with the HoHe score in at least one of the samples but for which no hypotheses were formulated. Following this, the regression model of sample 1 was tested in sample 2 and the regression model of sample 2 was tested in sample 1 by means of out-of-sample prediction. We also tested block-wise regression models by using only variables (i), variables (i) and (ii), and variables (i), (ii), and (iii). According to likelihood-ratio tests, the models including all of the blocks were best and are presented in this manuscript.

Finally, current voting intentions were investigated in light of the sociodemographic variables and the standardized root-square-transformed HoHe score (to meet assumptions of this kind of analysis) by means of linear discriminant analyses. In each sample, discriminant analysis functions were built and tested in the other sample, respectively.

Results

Descriptive statistics

Descriptive statistics for the continuous variables are presented in Table 1. The following distributions emerged for the item on current voting intentions:

Sample 1: DIE LINKE: $n=73$ (10.64%), SPD: $n=104$ (15.16%), Bündnis 90/Die Grünen: $n=129$ (18.80%), FDP: $n=61$ (8.89%), CDU/CSU: $n=180$ (26.24%), AfD: $n=67$ (9.77%), others: $n=36$ (5.25%), would not vote: $n=36$ (5.25%).

Table 1. Descriptive statistics (Mean and SDs) for sample 1 and sample 2.

	Sample 1 (*N*=686)	Sample 2 (*N*=702)
Openness	3.43 (0.63)	3.65 (0.62)
Conscientiousness	3.90 (0.58)	3.38 (0.68)
Extraversion	3.40 (0.75)	3.18 (0.85)
Agreeableness	3.58 (0.55)	3.47 (0.56)
Neuroticism	2.55 (0.78)	2.84 (0.79)
KSA-3	2.78 (0.80)	2.14 (0.64)
SDO scale	2.64 (0.93)	2.15 (0.88)
HoHe score	7.11 (7.15)	7.64 (6.00)

The HoHe score (see methods section for the formula) cannot be interpreted in absolute terms; a score of 7 could, for example, be achieved by consuming 7 media types, one source per media type, with a confrontation score of 1.00 per media type, $(1 \times 1 \times 1.00) \times 7 = 7$, or by consuming 7 media types, 2 sources per media type with a confrontation score of 0.50 per media type, $(1 \times 2 \times 0.50) \times 7 = 7$; note that in this table, mean scores across participants are presented. KSA-3 = Short Scale on Authoritarianism score; SDO = Social Dominance Orientation scale score; HoHe score = Homogeneity versus heterogeneity of political news consumption score.

Sample 2: DIE LINKE: *n*=91 (12.96%), SPD: *n*=67 (9.54%), Bündnis 90/Die Grünen: *n*=300 (42.74%), FDP: *n*=57 (8.12%), CDU/CSU: *n*=54 (7.69%), AfD: *n*=20 (2.85%), others: *n*=101 (14.39%), would not vote: *n*=12 (1.71%).

Table 1 presents the mean values of the HoHe scores. The range of the scores was 0.00–59.25 in sample 1 and 0.00–46.00 in sample 2 (not presented in Table 1). Figure 1 shows the distribution of the HoHe scores for both samples.

Focusing only on the number of news sources consumed across the media types (without considering the confrontation with counter-attitudinal news), a range of 1.00–63.25 was found in sample 1, and a range of 0.00–54.00 was found in sample 2 (decimal numbers are due to winsorization; 0.00 is possible because individuals can indicate they use a media type, but have not consumed news during the past 6 months via this media type; only one person had a score of 0.00 for the number of news sources consumed).

When focusing on the weights of confrontation with counter-attitudinal news, the means for different media types ranged from 0.37 (SD=0.23; Podcasts) to 0.55 (SD=0.25; social media) in sample 1, and from 0.34 (SD=0.24; Podcasts) to 0.50 (SD=0.21; online news websites) in sample 2; see Figure 2 or Supplementary Material. Similarly, the highest median scores were 0.50 (for all media types except podcasts) in sample 1 and also 0.50 for print media, online news websites, news aggregators, and social media in sample 2. Within single media types, several individuals responded to "never" being confronted with news contradicting their attitudes when consuming political news. However, only *n*=14 (sample 1) and *n*=3 (sample 2) individuals reported "never" being confronted with news contradicting their opinions when consuming political news for all media types they consumed.

Note that the results for the number of news sources consumed and the weights of being confronted with counter-attitudinal news per media type were not preregistered but were deemed important to understand the data more in-depth.
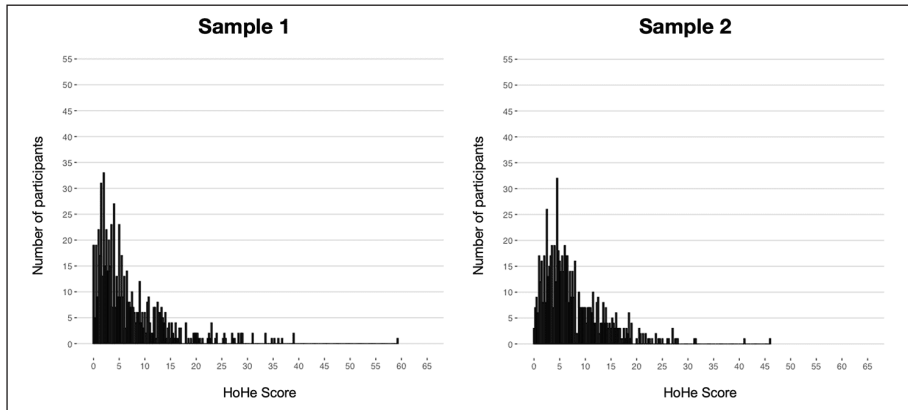
Figure 1. Histograms of homogeneity versus heterogeneity of political news consumption (HoHe) scores in samples 1 (left) and 2 (right).

Associations of personality and ideological attitudes with the degree of homogeneity versus heterogeneity of one's political news consumption scores

Correlational analyses (see Supplementary Material) revealed significant positive associations of the HoHe score with Openness (sample 1: $\rho = .26$, $p < .001$; sample 2: $\rho = .09$, $p = .012$) across both samples. Furthermore, Extraversion ($\rho = .13$, $p < .001$) and the KSA-3 scale ($\rho = -.09$, $p = .019$) were related to the HoHe score in sample 1. Agreeableness was negatively related to the HoHe score in sample 2 ($\rho = -.17$, $p < .001$)

The regression models predicting the square-root-transformed HoHe score are shown in Table 2. Significant positive associations with age, negative associations with gender (men > women), positive associations with Openness, and negative associations with Agreeableness were found in both samples (although the zero-order correlation of Agreeableness with the HoHe score was only significant in sample 2; see Supplementary Material). Adjusted R^2 values were .124 and .064 in samples 1 and 2, respectively. Within sample 1, the out-of-sample prediction revealed that the score calculated from the regression formula derived from sample 2 (and after squaring the score) significantly correlated with the actual HoHe score in sample 1: $\rho = .26$, $p < .001$. In sample 2, the correlation of the actual HoHe score with the score calculated from the regression formula derived from sample 1 was $\rho = .22$, $p < .001$.

Associations of the degree of homogeneity versus heterogeneity of one's political news consumption scores with voting intentions

Descriptive statistics of the HoHe score split by groups with different voting intentions can be found in Table 3.

Within both samples 1 and 2, four linear discriminants emerged. Coefficients are presented in Table 4. The model derived from sample 1 led to 28.28% correctly classified cases in sample 1. 43.18%, 33.20%, 20.40%, and 3.23% of separation were achieved by
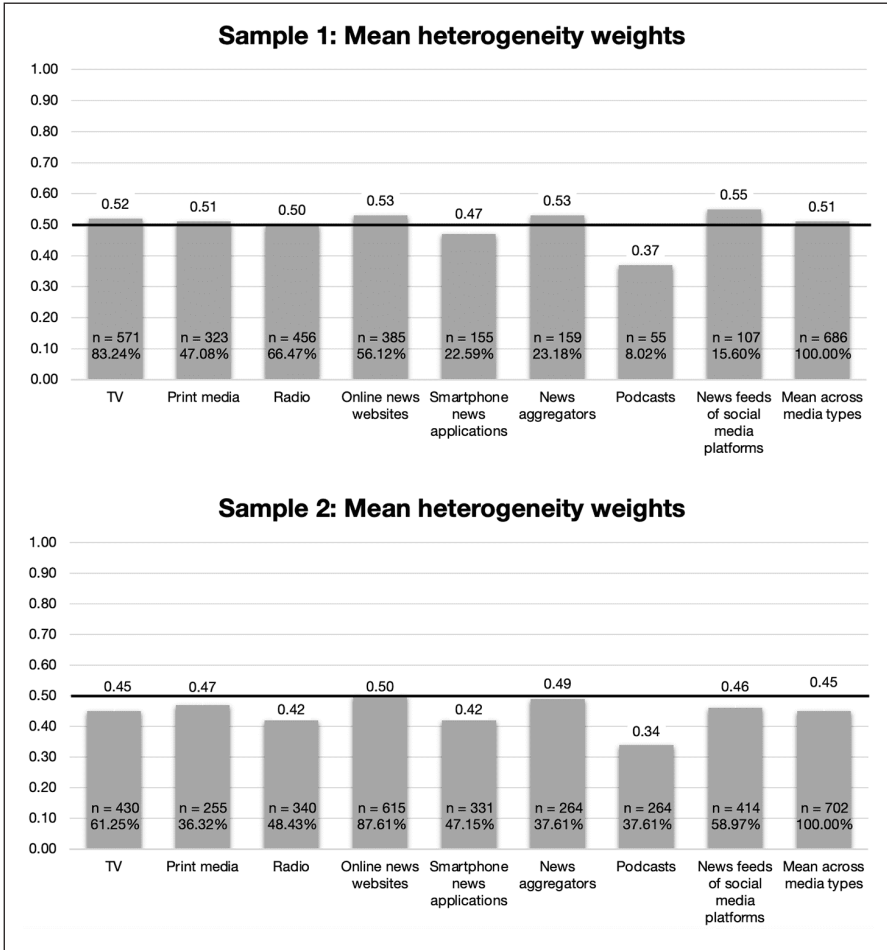
Figure 2. Mean scores of weights of being confronted with counter-attitudinal news for each media type and means across all media types used in samples 1 (top) and 2 (bottom).

linear discriminants (LDs) 1, 2, 3, and 4, respectively. The model derived from sample 2 led to 41.88% correctly classified cases in sample 2, which was solely due to the correct classification of $n = 294$ individuals who would vote for Bündnis 90/Die Grünen. 70.43%, 15.29%, 11.55%, and 2.74% of separation was achieved by LDs 1, 2, 3, and 4, respectively.

   Predictions from the model derived from sample 2 in sample 1 led to 18.66% correct classifications. However, 681 (of 686) times voting for Bündnis 90/Die Grünen was predicted, which was the largest group in sample 2. Thus, the predictions are not meaningful. Predictions by the model derived from sample 1 in sample 2 led to 16.67% correct classifications.

Table 2. Regression models predicting the square-root-transformed HoHe score.

	Sample 1				Sample 2			
	B	SE	t	p	B	SE	t	p
Intercept	2.34	0.07	35.30	<.001	2.60	0.06	47.19	<.001
Age	0.13	0.05	2.78	.006	0.13	0.04	3.06	.002
Gender	−0.24	0.09	−2.65	.008	−0.16	0.08	−1.98	.048
Education	0.45	0.10	4.65	<.001	0.07	0.09	0.73	.468
Openness	0.27	0.05	5.53	<.001	0.08	0.04	2.08	.038
KSA-3	−0.08	0.05	−1.82	.069	−0.05	0.04	−1.33	.182
Extraversion	0.09	0.05	1.95	.051	0.06	0.04	1.52	.130
Agreeableness	−0.12	0.05	−2.62	.009	−0.21	0.04	−5.29	<.001

The homogeneity versus heterogeneity of political news consumption (HoHe) score was square-root-transformed to more closely align with the prerequisites for regression analyses. Gender (0 = *men*, 1 = *women*) and education (0 = *no university degree*, 1 = *university [of applied sciences] degree*) were dummy coded; all other predictor variables were standardized. The correlations of HoHe scores for offline versus online media types are presented in the Supplementary Material.

Table 3. Descriptive statistics of the HoHe score split by groups of individuals with different voting intentions.

	DIE LINKE	SPD	Bündnis 90/Die Grünen	FDP	CDU/CSU	AfD	Others	Would not vote
Sample 1	9.83 (10.29) n = 73	6.78 (5.37) n = 104	6.32 (6.23) n = 129	8.73 (7.34) n = 61	5.96 (5.94) n = 180	9.28 (8.49) n = 67	7.37 (8.75) n = 36	4.05 (4.61) n = 36
Sample 2	8.59 (5.84) n = 91	8.91 (6.09) n = 67	6.71 (5.88) n = 300	8.14 (5.05) n = 57	7.08 (5.64) n = 54	10.07 (10.17) n = 20	7.98 (5.70) n = 101	9.43 (6.39) n = 12

Descriptive statistics of homogeneity versus heterogeneity of political news consumption (HoHe) scores for offline versus online media types are presented in the Supplementary Material.

Discussion

The current study sought to contribute empirical data to the ongoing discussions around homogeneous political information environments. Three specific aims were addressed in this study: (1) An examination of the degree of heterogeneity of information environments of individuals in relation to political news, (2) analyses of the extent to which the degree of heterogeneity of an individual's political information environment is associated with individual differences in sociodemographics and personality, and (3) an exploration of the associations of the degree of heterogeneity of individuals' political information environments with ideological attitudes and political voting intentions. Analyses focused on political news consumption across various offline and online media

Table 4. Coefficients for the linear discriminant analyses.

	Sample 1				Sample 2			
	LD1	LD2	LD3	LD4	LD1	LD2	LD3	LD4
Age	−0.58	0.66	0.26	0.49	−0.06	−0.86	0.67	−0.21
Gender	0.85	−0.28	0.45	1.80	−1.84	0.89	0.75	0.02
Education	−0.07	−0.51	2.12	−0.55	−0.35	−0.06	−1.01	2.10
HoHe score	−0.57	−0.75	−0.35	0.32	0.44	0.54	0.66	0.36

Gender (0 = men, 1 = women) and education (0 = no university degree, 1 = university [of applied sciences] degree) were dummy coded; age and the square-root-transformed homogeneity versus heterogeneity of political news consumption (HoHe) scores were standardized. LD: Linear discriminant. We acknowledge the critique on including categorical, i.e., non-continuous, variables in discriminant analysis but included the dummy-variables gender and education nevertheless. This is because several works mention that the inclusion of dummy variables is appropriate (e.g., Dillon & Westin, 1982) and because the in- and exclusion of the two dummy variables does not change the main finding that association between the HoHe score (main variable of interest) and voting intentions is inconsistent across samples 1 and 2.

types and were implemented in two independent population-based samples to derive robust, replicable, and reliable findings.

Across the two independent samples, the media type where individuals received on average the most homogeneous and attitude-consistent political news was podcasts; see Figure 2. It should be highlighted, however, that relatively few individuals in sample 1 (8.02%; but sample 2: 37.61%) actually used podcasts to consume political news. The generally low scores for consuming counter-attitudinal news via podcasts in both samples might be due to the time which needs to be invested into listening to a podcast. Given this, individuals might need to be more selective with regard to which podcast they listen to. It is also possible that individuals tend to choose to listen to podcasts delivered by specific individuals who then advertise podcasts by other individuals with similar attitudes, further reducing the heterogeneity of news consumption of listeners. The media types where individuals on average received the most heterogeneous political news were social media (sample 1) and online news websites (sample 2); see Figure 2. Thus, these results do not support the notion that social media platforms pose the greatest risk for homogeneous information environments (see arguments highlighted in the *Introduction* of the present study). In addition, the results do not show that political news consumed via online media types, where algorithmic filtering is possible, are generally more homogeneous than those consumed via offline media types. Unfortunately, we cannot draw any conclusion as to why heterogeneity scores differ between media types. Heterogeneity could be due to incidental, algorithmically based, or self-initiated confrontation with counter-attitudinal news. Investigating the reasons for differences in heterogeneity scores across media types will be an important research approach for forthcoming studies. Relatedly, mechanisms to increase the heterogeneity of news consumed within and across media types will need to be investigated. Based upon these investigations, citizens should be informed about the degree of heterogeneity of news presented via different media types and ways to increase heterogeneity. Further development of add-ons (e.g. for internet browsers) informing users about their personal heterogeneity of news consumption could be the first step in

this direction—an add-on is, however, always limited to the online context (see examples mentioned in Bozdag and van den Hoven (2015)).

Across all media types used, only a few individuals responded "never" to seeing news contradicting their existing opinions when consuming political news ($n = 14$, 2.04% in sample 1; $n = 3$, 0.43% in sample 2). These results indicate that few individuals are exposed to absolutely homogeneous information environments across media types. This is in line with previous research on incidental and counter-attitudinal news exposure on different media types (Newman et al., 2017; Vaccari et al., 2016).

Older age and being male (versus female) were associated with greater heterogeneity of one's political information environment across samples. These results fit with findings from previous studies (Benesch, 2012; Sindermann et al., 2020) although, in one of the cited studies significant associations with education were also found, which was only observed in one of our samples (sample 1).

With respect to individual differences in personality the following results were obtained: Significant positive associations of Openness (in correlational and regression analyses) and negative associations of Agreeableness (in regression analyses) with the degree of heterogeneity of political information environments were found across samples.

We want to specifically highlight the positive associations between Openness and the degree of heterogeneity of political information environments. These positive associations are in line with our initial hypothesis and the findings of previous studies (Matz, 2021; Sindermann et al., 2020). Moreover, it supports the intellectual stimulation hypothesis proposed by Kim and Kim (2018). Individuals scoring high in Openness seem to enjoy engagement in news reports dealing with a range of different political opinions. This is also in line with one study where a positive association between Openness and engagement in political discussions was reported (Mondak and Halperin, 2008); but we should also acknowledge the results of other studies that do not support this link (Gerber et al., 2012; Hibbing et al., 2011). As can be seen in Supplementary Table 5, Openness might be more strongly related to the degree of heterogeneity of one's online versus offline political information environment (see results from sample 1 reported in the Supplementary Material). A greater potential for the individual to create his or her online news environment versus the offline news environment might contribute to these differential associations (see Supplementary Material).

Contrary to our hypotheses, we did not find any significant association of ideological attitudes with the degree of heterogeneity of one's political information environment across samples. Despite RWA and SDO having been found to positively relate to closed-mindedness (Berggren et al., 2019), they do not seem to be related to the degree of heterogeneity of one's political information environment. Interestingly, however, additional analyses (Supplementary Material) revealed that RWA was negatively related to the heterogeneity of one's online, but not offline, political information environment across both samples. On the one hand, it is possible that high-choice online environments in particular offer the possibility for homogeneous political news consumption for individuals high in RWA. On the other hand, more information filtering online (e.g. via algorithms) compared to offline sources might influence RWA. These results and the causal direction of associations will need to be (re-)investigated in future studies.

It is difficult to draw any firm conclusions regarding potential associations between the degree of heterogeneity of one's political information environment and voting intentions. Lower heterogeneity was not associated with intentions of not voting, or to vote for a more extreme right-wing party, across samples. Models derived from linear discriminant analysis on associations of sociodemographic variables and the degree of heterogeneity of one's political information environment with voting intentions revealed quite low classification accuracies. Therefore, we should not overinterpret these particular findings. Future studies might want to examine the associations between the degree of heterogeneity of political information environments and political attitudes in German samples in a slightly different way. For example, one could investigate the strength of party support, topic polarization, affective/partisan polarization via the "feeling thermometer," or overall left–right ideological self-placement (e.g. Heatherly et al., 2017; Lee et al., 2014). Based on this idea, on an exploratory basis, we calculated the correlation between a 10-point left–right ideological self-placement item and the HoHe score in sample 2 (the left–right self-placement was only assessed in sample 2). The association was nonsignificant ($\rho = -.02$, $p = .660$). However, the association between an extremity score (absolute difference between self-placement on the left-right dimension and the mean scores 5 and 6) and the HoHe score was small but significant ($\rho = .08$, $p = .037$; these analyses were not preregistered). This indicates that these associations should be investigated in more depth in further studies to understand these complex relations.

Some limitations of the present study must be acknowledged. First of all, neither of the two samples is completely representative of the general German population. Moreover, it is important that the generalizability of the findings will be tested in future studies in other countries. Nevertheless, we are confident that the results that were replicated across the two samples of the present study will also be found in other samples. Next, it should be emphasized that data collection for both surveys was conducted in times of an exceptional crisis, namely, during the COVID-19 pandemic. Therefore, many news stories across different platforms are likely to have included information about the virus and legal/policy regulations to combat it (e.g. lockdowns, stay-at-home orders, etc.; GöfaK Medienforschung, 2020, as cited in Statista, 2021; tagesschau.de, 2020). The focus on these topics across news platforms might adversely affect the generalizability of findings and might explain findings that were inconsistent with our hypotheses. For instance, according to a recent survey, voters of the AfD were mostly against the measures to fight the COVID-19 pandemic (Forschungsgruppe Wahlen, 2020), which might (in part) explain high HoHe scores in this group. The present study should therefore be replicated when topics related to the pandemic are not dominating the news. Another limitation is that the present surveys were cross-sectional. Any conclusions about causality are limited, accordingly. One might, however, cautiously infer causal influences on the degree of heterogeneity of one's political information environment specifically for associations with sociodemographic variables and personality traits, which are generally seen as relatively stable (Costa and McCrae, 1992a; Edmonds et al., 2008; Roberts and Mroczek, 2008). Another limitation is the application of self-report measures. Assessment of personality, ideological attitudes, and voting intentions via self-reports might be influenced by response biases or lack of ability for introspection (McDonald, 2008). Also, the statements on how many news sources one consumed

within the past six months prior to participation, and on how often one was confronted with counter-attitudinal news, might be (un-)consciously biased. Nevertheless, the application of self-report measures allowed us to assess the degree of heterogeneity across various offline and online media types, which is very difficult to assess via objective methods. The HoHe score and its constituent items might be improved in future work, for example, by adding variables on the frequency of use, or the time spent on each media type. Another potential limitation is that across all results effect sizes were mostly small to medium, according to Cohen's (1992) rules of thumb. This indicates that the degree of heterogeneity of one's political news consumption, as well as voting intentions for a specific party, are complex psychological constructs and many different variables and their interactions contribute to explaining variance in them, with each single variable only having a small effect (Götz et al., 2021).

Conclusion

In conclusion, the results of the present study indicate that absolutely homogeneous political information environments across various media types might exist for a small proportion of individuals. Next to age and gender, the personality traits Openness (positively) and Agreeableness (negatively) seem to be associated with the degree of heterogeneity of an individual's political information environment, especially for online media types (see Supplementary Material). This knowledge can support targeting certain groups for information campaigns in the future. In particular, individuals high in Agreeableness and low in Openness might profit from being informed about highly homogeneous political information environments and putative threats arising from them. Finally, no definite conclusion about associations between the degree of heterogeneity of an individual's political information environments and voting intentions can be drawn from the present findings. Future studies should investigate other measures of political attitudes to shed further light on putative associations. In addition, longitudinal studies would be of great importance in investigating potential causal effects in these associations.

Authors' note

Authors' contribution

Declaration of conflicting interests

German Research Foundation (DFG). Dr. Montag has performed grant reviews for several agencies; has edited journal sections and articles; has given academic lectures in clinical or scientific venues or companies; and has generated books or book chapters for publishers of mental health texts. For some of these activities he received royalties, but never from gaming or social media companies. Dr. Montag mentions that he is part of a discussion circle (Digitalität und Verantwortung: https://about.fb.com/de/news/h/gespraechskreis-digitalitaet-und-verantwortung/) debating ethical questions linked to social media, digitalization and society/democracy at Facebook. In this context, he receives no salary for his activities. Finally, he mentions that he currently functions as independent scientist on the scientific advisory board of the Nymphenburg group. This activity is financially compensated.

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Supplemental material

Supplemental material for this article is available online.

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