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Exploring Disinformation: The interplay of exposure, trust, and sharing

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ABSTRACT

Disinformation, defined as false information deliberately created and communicated as true to influence beliefs or behavior, poses a growing threat to democratic societies and public discourse. This study examined patterns of disinformation exposure, trust, and sharing among adults in the Czech Republic—a small European democratic country. Using survey data from 3240 participants collected in June 2023, we investigated how sociodemographic factors relate to these dimensions of disinformation engagement.

Findings show that older individuals, those with lower educational attainment, and women are more likely to trust disinformation. Prior exposure was strongly associated with increased trust in disinformation narratives, consistent with the familiarity effect described in prior research. Trust, in turn, was the strongest predictor of sharing behavior, suggesting that disinformation is often spread by individuals who genuinely believe it, rather than by deliberate deceivers.

By combining real-world narratives with a standardized assessment framework, this study provides insight into who is most vulnerable to disinformation and why. These findings contribute to a deeper understanding of how disinformation circulates in the general population and which groups are most susceptible.

1. Introduction

The digital age brings new challenges as information spreads rapidly within a system of increasing complexity. In today's society, information serves as a cornerstone of progress and innovation. It fuels decision-making, drives economic growth, and empowers individuals by providing access to knowledge and resources. With the rapid advancement of technology, the ability to gather, analyze, and disseminate information efficiently has become crucial. This interconnected flow of information fosters global communication, enhances education, and supports democratic processes by keeping citizens informed and engaged. However, as the importance of information increases, so do the risks related to its misuse, manipulation, and distortion—commonly referred to as information disorders.

1.1. The definition and impact of disinformation

Information disorders can be classified into several categories: misinformation (false information shared without the intent to deceive; e.g., disseminating outdated content), disinformation (false information created with the intent to deceive and cause harm; e.g., the false claim that a prominent politician opened an offshore bank account), and malinformation (true information used with the intent to harm, such as disclosing private information out of context) (Wardle & Derakhshan, 2017). Building on this typology, disinformation can be defined as "information that is (i) false, (ii) communicated as true, and (iii) intentionally communicated as true in order to influence people's beliefs or behavior" (Kwek et al., 2023).

Although the overall consumption of disinformation is relatively low compared to general news consumption (Allen et al., 2020; Fletcher et al., 2018), its impact has raised significant concern due to its role in shaping a wide range of major societal events, including but not limited to elections (Dragomir et al., 2024; Lazer et al., 2018; Morgan, 2018), the COVID-19 pandemic (Pian et al., 2021; Sánchez Del Vas & Tuñón Navarro, 2024; Van Der Linden, 2022), the Russia–Ukraine war (Sánchez Del Vas & Tuñón Navarro, 2024), and climate change debates

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(Treen et al., 2020).

Although studies directly examining the psychological effects of disinformation on individual well-being remain relatively limited (Akram et al., 2022), some correlational evidence from the COVID-19 context suggests that uncritical exposure to disinformation narratives was associated with increased symptoms of depression and anxiety (De Coninck et al., 2021), as well as with reduced trust in institutions and lower compliance with public health regulations (Pummerer et al., 2022).

Overall, disinformation has been shown to be harmful not only to democratic institutions, but also to individual psychological well-being (Ecker et al., 2024), and addressing it has been declared a top priority by experts in public relations, journalism, information systems, and other fields (OECD, 2024).

1.2. High-impact political disinformation

Not all forms of disinformation carry the same societal weight, and experts have called for prioritizing those with the greatest potential for harm—particularly politically motivated narratives with polarizing effects (Ecker et al., 2024).

Political disinformation campaigns, in particular, have the potential to undermine trust in institutions, fuel ideological divides, and erode democratic norms—and these effects are increasingly visible in the rising societal tensions observed across many democracies (French et al., 2024).

A recent typology proposed by French et al. (2024) distinguishes between four types of disinformation campaigns based on two key dimensions: impact (inconsequential vs. consequential) and intentionality of the spreaders (intentional vs. unintentional) (French et al., 2024).

The typology outlines the following categories:

1. Trivial deceivers: spreaders who intentionally disseminate low-impact disinformation, such as satire, trolling, or banter. These messages are typically easy to recognize as false and, while they may be shared widely, they pose minimal risk of serious societal harm.
2. Trivial misleaders: individuals who unintentionally spread low-impact disinformation narratives. These messages are often perceived as plausible or consistent with one's beliefs, but lack significant potential for polarization or disruption.
3. Influential misleaders: spreaders who believe the disinformation to be true, but the narratives they share are high-impact and polarizing. This group plays a key role in amplifying the societal consequences of disinformation, as the content appears authentic to them and is more likely to gain traction.
4. Influential deceivers: actors who know the information is false but disseminate it intentionally to advance a particular agenda—e.g., political gain, financial profit, or ideological influence. These campaigns are both high-impact and deliberately manipulative.

Based on their analysis of disinformation campaigns related to the last three U.S. presidential elections, French et al. (2024) found that most high-impact campaigns were driven by influential misleaders—individuals who genuinely believed the false narratives they were sharing (French et al., 2024). This finding is particularly important for understanding how political disinformation spreads: when people believe false content to be true, they are more likely to share it sincerely and with conviction, increasing its reach and persuasive potential.

1.3. Susceptibility to trust disinformation

Given the central role of belief in the spread of political disinformation, understanding who is most likely to trust such content is critical. Several sociodemographic factors have been identified as predictors of susceptibility to disinformation. A recent meta-analysis summarizing U.S.-based studies using the experimental news headline paradigm with a nonconfounded measure of veracity found that age was the only variable with a significant effect: older adults demonstrated overall higher discrimination accuracy (i.e., correctly identifying true and false news) but also showed greater general distrust, leading to a so-called "false-news bias" (Sultan et al., 2024).

While these findings are based on a robust and unified methodological paradigm, they are geographically limited to the United States. In contrast, a recent narrative review focused specifically on disinformation in social media environments provides a complementary perspective based on a more diverse set of countries. Chen et al. (2023) summarize findings from studies conducted in India, Spain, the Netherlands, and Saudi Arabia, which consistently show that older individuals tend to exhibit lower skepticism, greater acceptance of false content, and a higher likelihood of sharing it on social platforms (Chen et al., 2023). This suggests that the relationship between age and disinformation vulnerability may depend on both the broader media environment and the context in which the content is encountered.

Further evidence of cross-national variation is provided by a large comparative study, which found that while older age was negatively associated with disinformation sharing in the U.K. and U.S., it was positively associated with such behavior in several continental European countries, including Belgium, France, Germany, and Switzerland (Humprecht et al., 2023).

Education has also emerged as a consistent factor across many studies: individuals with lower levels of education tend to be more vulnerable to believing false content (Baptista & Gradim, 2020; Chen et al., 2023; Schaewitz et al., 2020; Wolverton & Stevens, 2019). However, there is also evidence that even highly educated individuals may struggle to reliably evaluate online information if they do not use appropriate strategies. For instance, Wineburg and McGrew (2019) showed that professional fact-checkers outperformed both academics and students from elite universities in assessing the credibility of online sources—not because of superior knowledge, but because they employed effective techniques such as lateral reading (i.e., quickly consulting multiple outside sources), rather than relying on close reading of the page itself (Wineburg & McGrew, 2019). These findings highlight that general education may not be sufficient for resisting disinformation in digital environments unless paired with specific digital literacy skills.

While age and education have been most consistently studied, gender-related patterns appear to be more variable. The recent meta-analysis by Sultan et al. (2024) found no credible effect of gender on discrimination accuracy, although a small but credible gender difference emerged in response bias: female participants were more likely to classify headlines as false, resulting in higher accuracy for false headlines but slightly lower accuracy for true ones. A review focused on social media environments also reported mixed findings, with some studies suggesting greater susceptibility to misinformation among men and others among women (Chen et al., 2023).

These findings highlight the importance of examining susceptibility to disinformation across different sociocultural contexts. Sociodemographic characteristics such as age, education and gender may interact with country-specific factors—including media ecosystems, levels of digital literacy, and trust in institutions—as suggested by recent models of information resilience (Dragomir et al., 2024).

Another important factor influencing belief in disinformation is prior exposure. The meta-analysis by Sultan et al. (2024) reported a large familiarity effect, showing that previous exposure to headlines increased the likelihood that participants would judge them as true—regardless of their actual veracity. However, only six studies in the meta-analysis directly examined this relationship (Sultan et al., 2024).

This finding is consistent with the illusory truth effect—the well-documented tendency to perceive repeated information as more accurate than novel statements. The effect is thought to be driven by processing fluency: repeated content is easier to process cognitively, and this fluency is misinterpreted as a signal of truth (Alter & Oppenheimer,

2009). Notably, this bias occurs even when individuals possess factual knowledge that contradicts the repeated claim (Fazio et al., 2015), and it has been demonstrated specifically in the context of fake news (Pennycook et al., 2018).

In addition, the relationship between exposure and perceived trustworthiness may be reinforced by selective exposure to ideologically congruent content, which feels familiar and comforting (Kim et al., 2021). As shown in the meta-analysis, ideological congruency between the headline and the respondent's political orientation was strongly associated with response (or partisan) bias—that is, judging ideologically consistent content as true and inconsistent content as false (Sultan et al., 2024).

1.4. From trust to sharing

While belief in the truthfulness of disinformation is not the only reason why people share it, perceived credibility appears to be a strong predictor of sharing behavior. For example, Hopp (2022) found that the perceived veracity of disinformation headlines was negatively associated with participants' ability to recognize them as false—suggesting that those who judged disinformation as more believable were also more likely to share it (Hopp, 2022). Nevertheless, many studies examining susceptibility to disinformation have deliberately excluded sharing behavior from their designs, to ensure that trust ratings reflected credibility judgments based on content alone (Sultan et al., 2024).

At the same time, sharing is not evenly distributed across the population. A small subset of individuals may act as powerful amplifiers: during the 2020 U.S. presidential election, just 0.3 % of Twitter users were responsible for 80 % of tweets linking to false information sources—a group labeled as supersharers (Baribi-Bartov et al., 2024). These individuals not only shared an average of three links to false content per day, but also engaged with political content far more intensively than the rest of the sample. Although supersharers reached only a fraction of the overall user base, their influence was substantial—followers of a supersharer were 2.5 times more likely to be exposed to fake news links.

Together, these findings underscore the importance of examining exposure, trust, and sharing not as isolated phenomena but as interconnected processes. They also highlight the need to identify individuals or groups most likely to act as disinformation spreaders—whether due to high trust, high activity, or both. Addressing these questions requires a more integrated approach that captures the complexity of real-world disinformation dynamics and can inform targeted interventions.

1.4.1. Gaps and our study

Despite growing evidence on individual differences in susceptibility to disinformation, several gaps remain. First, disinformation research has so far focused predominantly on Western democracies such as the United States and the United Kingdom. However, some countries in Central and Eastern Europe—including the Czech Republic—are particularly vulnerable to foreign influence campaigns, in part due to historical and geopolitical factors (Baqués-Quesada & Colom-Piella, 2021; Dragomir et al., 2024). Second, the dominant methodological approach in this area—the experimental news headline paradigm—typically isolates the evaluation of veracity from other aspects of disinformation dynamics, such as exposure and sharing behavior. While this paradigm ensures experimental control and allows for causal inferences, it may not fully reflect how people interact with disinformation in real-life contexts.

Moreover, many studies focus exclusively on either trust or sharing, while the relationship between the two remains understudied. To better understand the mechanisms of disinformation spread, it is important to examine exposure, trust, and sharing in an integrated framework.

Our study addresses these limitations by analyzing disinformation engagement in a representative sample of adults from the Czech Republic. Unlike experimental studies using decontextualized headlines, we presented participants with full political disinformation narratives that were actually circulating in the information environment at the time of data collection. To avoid confounding effects related to source credibility, all materials were shown without source attribution, a factor known to influence trust judgments (Sultan et al., 2024). This approach was designed to more closely approximate real-world exposure and to allow for simultaneous analysis of exposure, perceived trustworthiness, and sharing behavior.

Our aim was to assess (i) the extent to which people are exposed to disinformation narratives, (ii) how trustworthy they perceive them to be, and (iii) whether they share them further. We also examined the relationships between these variables and identified sociodemographic groups most susceptible to trusting and sharing disinformation.

2. Methods

2.1. Setting

This study was a part of the ongoing longitudinal project focused on the information and media literacy among citizens of the Czech Republic. This study used data from the fourth wave of data collection in the Czech Republic conducted in June 2023.

2.2. Data collection

Data were collected using national online panel company, which adheres to the ICC/ESOMAR International Code on Market, Opinion and Social Research and Data Analytics, which sets the standard of ethical and professional conduct for the global data, research and insights community. The sample included Czech-speaking individuals aged 16 years and older. While the formal age of legal majority in the Czech Republic is 18, individuals aged 16 and above are commonly included in nationally representative surveys on media use and public opinion, particularly those related to digital behavior and attitudes. This age threshold aligns with practices used by major polling agencies and ensures comparability with existing research in this area. The sample was balanced for age, gender, education, region, size of the place of the residence, internet use, occupational status, and voting behavior (the last presidential elections, and the last parliament elections[1]) in order to well represent the adult Czech population. A total of 3994 eligible persons were invited to participate, 3480 agreed to participate and entered the online survey (response rate 87.1 %). From them, 40 participants were excluded based on quota, 130 did not complete the survey. Participants were rewarded for the completion of survey. In total, 3310 participants completed survey. Of them, 70 questionnaires were excluded based on the short duration of completion, and 3240 constituted the final sample. Data were collected during June 2023. The average questionnaire completion time was 30.5 min. When calculated without the most extreme 10 % of responses, the trimmed mean was 29.0 min.

2.3. Participants

The final sample (n = 3240) consisted of 52 % of women, had high proportion of older people (28 % over 65 years), high proportion of people with high school education (40 %), more people living in towns and cities than in rural areas, and high proportion of frequent internet users (70 %), which represented well the target population of citizens of the Czech Republic. The characteristics of sample are shown in Table 1.

[1] The Czech Republic has a multiparty parliamentary system. At the time of data collection, key political parties represented a range of ideological positions (e.g., ANO – centrist/populist, ODS – conservative, Piráti – liberal/progressive, SPD – nationalist), allowing us to use party preference as a proxy for ideological diversity in the sample.

Table 1
Characteristics of sample (N = 3240).

Variable	N	Percentage
Sex (assigned at birth)		
Female	1680	51.9
Male	1560	48.1
Age group		
16–24 years	226	7.0
25–34 years	373	11.5
35–44 years	553	17.1
45–54 years	579	17.9
55–64 years	596	18.4
65+ years	913	28.2
Education		
Elementary	256	7.9
Practical	1008	31.1
High school	1281	39.5
University	695	21.5
Size of the residence		
Less than 999 inhabitants	519	16.0
1000–4999 inhabitants	715	22.1
5000–19 999 inhabitants	584	18.0
20 000–99 999 inhabitants	666	20.6
More than 100 000 inhabitants	756	23.3
Internet usage		
More than once per day	2266	69.9
Approximately once per day	729	22.5
Less than once per day	245	7.6
Social media usage		
More than once per day	1325	40.9
Approximately once per day	406	12.5
More than once per week	340	10.5
Approximately once per week	157	4.8
Less than once per week	1012	31.2

2.4. Measures

Sociodemographic variables, e.g., age, gender, education, region, size of the residence, economic situation, were collected.

Disinformation. Seven disinformation narratives and three verified true news items were selected by media experts based on their relevance and salience in the Czech information environment at the time of data collection. The disinformation items were chosen using the following criteria: (a) their demonstrable presence and popularity in Czech online media and social networks, (b) their potential to polarize public opinion, and (c) their thematic relevance to dominant political discourses (e.g., Russian aggression in Ukraine, EU regulation, US military presence in Czechia). All selected disinformation narratives represented real examples of misinformation or disinformation that had been actively circulating in the public sphere. The true news pieces were similarly selected to match the political content and format and were verified through an independent fact-checking procedure. All narratives were presented as plain text without any additional contextual or visual cues (e.g., source labels, images, or formatting elements) to minimize confounding effects and to isolate participants' judgments of credibility and sharing behavior. Participants were asked to respond for each one narrative (1) whether they encounter it, and (2) whether they shared it. In the second step, all ten narratives (disinformation and factual news) were again presented, and participants rated to what extent they found them to be trustworthy (the response options were: completely trustworthy/rather trustworthy/rather untrustworthy/completely untrustworthy). The order in which narratives were presented was randomized across participants. Three variables concerning disinformation were derived:

(i) *the exposure to disinformation* was operationalized as the number of disinformation narratives (out of 7) that participants recognized as previously encountered (range: 0–7). Based on this, participants were categorized into four exposure groups: Unexposed (0), Mildly exposed (1–2), Moderately exposed (3–4), and Highly exposed (5–7).

(ii) *the spreading of disinformation.* A dummy variable (yes/no) was established to categorize all participants based on whether they shared at least one disinformation narrative out of seven which were presented. In addition, for participants, which reported to previously encounter at least one disinformation narrative (i.e., had an opportunity to share disinformation), the ratio of disinformation (0–100 %), which were shared was computed.

(iii) *the susceptibility to trust disinformation and discernment.* We calculated the number of disinformation narratives (0–7) that each participant evaluated as *rather* or *completely* trustworthy. In addition, we computed a **mean susceptibility score** (range 0–2) by assigning 1 point for each "rather trustworthy" rating and 2 points for each "completely trustworthy" rating, and dividing the total by the number of disinformation items (7). The internal consistency of this scale was good (Cronbach's $\alpha = 0.815$, McDonald's $\omega = 0.819$). The same procedure was applied to the three factual news items. Internal consistency for the **news trust scale** was lower (Cronbach's $\alpha = 0.644$, McDonald's $\omega = 0.652$). To capture the difference between the two types of trust, we computed a **discernment score**, defined as the difference between the mean trust score for factual news and the mean trust score for disinformation. Higher values indicate greater ability to distinguish between trustworthy and untrustworthy content. This measure is conceptually aligned with prior research on truth discernment in misinformation studies (e.g., Pennycook & Rand, 2021). For descriptive purposes, we also created a categorical index of **relative susceptibility to trust disinformation**, with the following groups:

- **Distrusting**: Participants who rated all items (both disinformation and news) as untrustworthy;
- **Neutral**: Participants whose mean scores for disinformation and factual news differed by less than 0.1;
- **Trusting news more**: Participants with a higher mean score for factual news;
- **Trusting disinformation more**: Participants with a higher mean score for disinformation.

2.5. Statistical analyses

We used a combination of descriptive, inferential, and multivariate analyses to examine disinformation-related behaviors in a representative sample. All analyses were conducted in Jamovi (jamovi, 2022; Lenth, 2020; R Core Team, 2022) Visualizations were generated using matplotlib and seaborn libraries in Python (version 3.11).

2.5.1. Variable types

The outcome variables included both ordinal and interval-level measures:

- Exposure to disinformation and factual news was assessed as the number of narratives recognized (0–7 for disinformation, 0–3 for factual news). These were treated as ordinal variables, and categorized into four levels (unexposed, mildly exposed, moderately exposed, highly exposed) for descriptive and regression analyses.
- Susceptibility to trust disinformation and factual news was measured in two ways: (1) as the number of narratives perceived as rather or completely trustworthy (0–7), and (2) as a mean score (0–2). For inferential analyses, the number of trusted items was treated as ordinal, while the mean scores were considered interval-level.

- Discernment was calculated as the difference between the mean trust in factual news and disinformation narratives (range: −1.71 to 2.00) and treated as an interval-level variable.
- Sharing behavior was operationalized as a binary variable (any vs. no sharing) as well as a count (0–7 for disinformation; 0–3 for factual news) and sharing proportion (ratio of narratives shared among those recognized).

Sociodemographic variables (age, gender, education) were treated as categorical predictors.

2.5.2. Statistical methods

Analyses proceeded in three steps:

1. Descriptive statistics were reported for all key variables, including means, standard deviations, and proportions. Where relevant, Spearman correlations were used to assess relationships between variables due to non-normal distributions.
2. Group differences were examined using:
   - Chi-square tests for associations between categorical variables (e.g., gender and exposure category);
   - Mann-Whitney U tests or Welch's *t*-tests for two-group comparisons;
   - ANOVAs or Kruskal-Wallis tests for multiple-group comparisons;
   - The choice between parametric and non-parametric methods was based on distributional properties. Most behavioral outcomes (e.g., number of narratives shared or trusted) were skewed and did not meet the assumptions of normality or homoscedasticity. However, when comparing subgroups (e.g., gender or education differences), we used parametric tests (e.g., Welch's *t*-test) despite violations of normality, due to the large sample size, the robustness of the test, and the interpretability of effect sizes such as Cohen's *d*. These choices were made to balance statistical appropriateness with clarity of communication.
3. Regression models were used to assess predictors of each outcome variable:
   - Ordinal logistic regression was used for ordinal outcomes (e.g., level of exposure or the number of trusted disinformation narratives);
   - Binary logistic regression was used for dichotomous outcomes (e.g., shared vs. not shared);
   - Linear regression was used for the discernment score, which had an approximately normal distribution;
   - Narrative-level analyses of perceived trustworthiness and sharing were conducted using separate binary logistic regression models for each narrative, restricted to participants who had been exposed to that narrative. Marginal probabilities were computed to illustrate predicted sharing likelihood conditional on perceived trustworthiness.

All models reported odds ratios (ORs), confidence intervals (95 % CI), and McFadden's R^2 for model fit. Effect sizes (e.g., Cohen's *d*, rank biserial correlations) were reported for group comparisons. Given the large sample size, the statistical tests were considered as significant if $p < .01$ (Maier & Lakens, 2022).

2.6. Ethics

Although the study involved the presentation of disinformation narratives, immediate debriefing of participants was not conducted due to the longitudinal nature of the project. Early debriefing could have compromised the validity of subsequent waves by sensitizing participants to the study aims. This approach was reviewed and approved by ethical committee of General University Hospital Prague (IORG0002175). Participants were informed that the study involved sensitive content and were provided with contact details for the research team in case of any questions or concerns. A full debriefing—including clarification of the nature and purpose of the narratives—is planned after the final wave of data collection in 2026. All subjects provided informed consent. The study procedures were carried out in accordance with the Declaration of Helsinki and was approved by.

3. Results

3.1. Descriptive results

In this section, we summarize descriptive findings related to the three key outcome variables: exposure to disinformation, perceived trustworthiness of disinformation, and sharing behavior.

Exposure to disinformation. Approximately one third of participants (34.2 %) reported not recognizing any of the seven disinformation narratives presented. In contrast, 6.5 % recognized five or more. The average number of recognized disinformation narratives was 1.60 (SD = 1.67; Median = 1, Range = 0–7). Recognition of factual news items followed a similar pattern: 39.3 % of participants were not familiar with any of the three factual news items, while 5.7 % were familiar with all of them. The average number of recognized news items was 0.90 (SD = 0.89; Median = 1, Range = 0–3). Exposure to disinformation and exposure to factual news were moderately positively correlated (Spearman's $\rho = 0.38$, $p < .001$).

Perceived trustworthiness. On average, participants rated 1.98 of the disinformation narratives as rather or completely trustworthy (SD = 2.08; Median = 1). One third of the sample (33.3 %) did not trust any disinformation narratives, while 4.6 % trusted all of them. Trust in factual news was generally higher, with a mean of 0.70 (SD = 0.56; Median = 0.67), compared to a mean of 0.35 (SD = 0.42; Median = 0.29) for disinformation. Most participants trusted factual news more than disinformation, but nearly 20 % trusted disinformation more. Finally, 13.5 % of participants did not trust any of the disinformation narratives or factual news items. Trust in disinformation and factual news was moderately positively correlated (Spearman's $\rho = 0.22$, $p < .001$).

Sharing behavior. Across the entire sample, only 10 % of participants (N = 310) reported sharing at least one disinformation narrative. Among those who had encountered at least one disinformation item (N = 2131), the majority (86 %) did not share any, while 3.2 % (N = 68) reported sharing all the disinformation narratives they had encountered. On average, participants shared 0.18 disinformation items (SD = 0.70), corresponding to 8.2 % of the recognized disinformation narratives (SD = 22.4 %). Sharing of factual news was less common in absolute terms: 5.6 % of participants reported sharing at least one factual news item. The average number of shared news items was 0.07 (SD = 0.33), corresponding to 6.9 % of recognized news (SD = 23.1 %). The proportion of disinformation and factual news narratives shared was moderately correlated (Spearman's $\rho = 0.30$, $p < .001$), suggesting some consistency in individual sharing tendencies across content types.

3.2. Sociodemographic differences

In the following subsections, we examine differences in disinformation exposure, trust, and sharing across three key sociodemographic variables: age, gender, and education.

3.2.1. Age

Exposure to disinformation significantly varied by age, $\chi^2(15) = 98.2$, $p < .001$. Participants over the age of 55 were less likely to be unexposed (<30 %) compared to younger groups (Supplementary Table S1). In contrast, 53 % of the youngest participants (aged 16–24) reported no prior exposure to any of the seven disinformation narratives. Approximately one third of the oldest participants (>65 years) were at least moderately exposed. Age was positively but weakly correlated with exposure to both disinformation (Spearman's $\rho = 0.16$, $p < .001$) and

factual news (ρ = 0.19, $p < .001$).

Significant age differences were also observed in perceived trustworthiness of disinformation, $\chi^2(35) = 83.9$, $p < .001$. The number of disinformation narratives rated as trustworthy increased with age (Supplementary Table S2). While 40 % of the youngest group (16–24) did not find any of the narratives trustworthy, this was true for only 29 % of the oldest group. Conversely, the proportion of participants who trusted all disinformation narratives was close to 0 % among the youngest, but reached 5–6 % among those aged 45 and older. However, the correlation between age and the total number of trusted disinformation narratives was weak (ρ = 0.13, $p < .001$), and there was no significant association between age and discernment score (ρ = −0.03, $p = .13$).

Sharing behavior also differed by age group, $\chi^2(5) = 19.4$, $p = .002$. Older participants were more likely to report sharing disinformation (Supplementary Table S3). Yet again, the correlations were weak for both the total number of disinformation narratives shared (ρ = 0.08, $p < .001$) and the ratio of shared to encountered narratives (ρ = 0.05, $p = .012$). Interestingly, age was negatively associated with the sharing of factual news: both the total number shared (ρ = −0.03, $p = .13$) and the proportion shared (ρ = −0.08, $p < .001$) declined with increasing age.

3.2.2. Gender

The level of exposure to disinformation differed slightly between men and women: $\chi^2(3) = 10.2$, $p = .017$, with women more often classified as unexposed compared to men (see Supplementary Table S4). However, this effect was small and not consistently supported by mean comparisons. A *t*-test showed no significant gender difference in the average number of recognized disinformation narratives (MD = 0.11, $t(3238) = 1.91$, $p = .057$, Cohen's $d = 0.07$). In contrast, men reported significantly higher exposure to factual news (MD = 0.36, $t(3238) = 11.79$, $p < .001$, $d = 0.42$).

Gender differences were more pronounced in the trust domain. Women were more likely than men to rate disinformation narratives as trustworthy: $\chi^2(7) = 39.0$, $p < .001$ (Supplementary Table S5). This was supported by mean comparisons, which showed higher trust in disinformation among women (MD = −0.05, Welch's $t(3237) = -3.76$, $p < .001$, $d = -0.13$), and higher trust in factual news among men (MD = 0.21, Welch's $t(3152) = 11.10$, $p < .001$, $d = 0.39$). Men also showed higher discernment scores (MD = 0.27, Welch's $t(3036) = 12.41$, $p < .001$, $d = 0.44$).

Sharing of disinformation narratives did not significantly differ by gender. Similar proportions of men (9.0 %) and women (10.1 %) reported sharing at least one disinformation narrative ($\chi^2(1) = 0.975$, $p = .324$, OR = 1.13, 95 % CI: 0.89–1.42; see Supplementary Table S6). No significant gender differences were found in the number of disinformation narratives shared (MD = −0.01, $t(3238) = 0.57$, $p = .567$, $d = -0.02$) or in the proportion of encountered narratives that were shared (MD = −1.77 %, Welch's $t(2102) = -1.82$, $p = .069$, $d = -0.08$). Men shared more factual news than women in terms of total number shared (MD = 0.04, Welch's $t(3114) = 3.35$, $p < .001$, $d = 0.12$), while the difference in the proportion of shared news items (8 % vs. 6 %) did not reach the statistical significance threshold (MD = 2.30 %, $t(1943) = 2.23$, $p = .026$, $d = 0.10$).

3.2.3. Education

The level of exposure to disinformation differed significantly across educational groups: $\chi^2(9) = 39.3$, $p < .001$. Participants with university degrees had the lowest proportion of those highly exposed to disinformation narratives, while those with only elementary education had the highest proportion (Supplementary Table S7).

Susceptibility to trust disinformation narratives was also significantly associated with education: $\chi^2(21) = 102.0$, $p < .001$. Among participants with university education, 43 % did not find any of the disinformation narratives trustworthy, while this proportion was notably lower in other groups (27–34 %). Conversely, only 1 % of university-educated participants trusted all disinformation narratives, compared to 5–6 % in other groups (Supplementary Table S8).

Mean comparisons revealed significant differences between educational groups across all three trust-related variables: trust in disinformation ($F(3, 1011) = 36.2$, $p < .001$), trust in factual news ($F(3, 994) = 15.5$, $p < .001$), and discernment score ($F(3, 1013) = 52.5$, $p < .001$).

Participants with university education reported the lowest average trust in disinformation (M = 0.24), significantly lower than all other groups (Table 2). Post-hoc comparisons confirmed these differences, with the largest gap observed between university-educated participants and those with practical education (MD = 0.20, $p < .001$).

Trust in factual news increased with higher levels of education. University-educated participants reported the highest average trust in factual news (M = 0.81), significantly higher than in other groups (all $p < .01$).

Discernment, defined as the difference between trust in factual news and trust in disinformation, was also highest among university-educated participants (M = 0.57). Post-hoc tests showed that this group scored significantly higher than all others, with the largest difference observed between university-educated and practically educated participants (MD = 0.38, $p < .001$).

The proportion of disinformation sharers was significantly affected by education ($\chi^2(3) = 36.0$, $p < .001$): participants with low education had higher proportion of disinformation sharers (Table S9). This pattern was further supported by mean comparisons. Both the total number of disinformation narratives shared (Welch's $F(3, 982) = 16.06$, $p < .001$) and the proportion of encountered disinformation that was shared (Welch's $F(3, 621) = 14.30$, $p < .001$) differed significantly across education groups. Participants with elementary or practical education shared more disinformation than those with higher education. For example, the mean number of disinformation narratives shared was 0.26 (SD = 0.85–0.87) among the least educated participants, compared to only 0.07 (SD = 0.38) among university graduates. Post hoc tests (Games-Howell) confirmed that participants with university education differed significantly from all other groups ($p < .001$). Similarly, the proportion of shared disinformation was highest among the least educated group (13.4 %) and lowest among those with university education (3.7 %).

In contrast, sharing of factual news did not significantly differ by education level. Neither the total number of factual news items shared (Welch's $F(3, 973) = 0.78$, $p = .504$), nor the proportion shared from those encountered (Welch's $F(3, 534) = 1.72$, $p = .162$) showed statistically significant differences. This suggests that educational differences in sharing behavior are more pronounced in the context of disinformation than in the context of factual news.

3.2.4. Combined effects of sociodemographic variables

To assess the unique contributions of age, gender, and education, we conducted multivariate models for each of the three main disinformation-related outcome variables: exposure, susceptibility to trust, and sharing. All predictors (except gender) were significant in the models, although their relative importance differed.

For **exposure to disinformation**, age emerged as the strongest predictor. Participants over 55 years had approximately three times higher odds of being exposed to disinformation than those aged 16–24. Gender and education also played a role, with men and participants with lower education being slightly more likely to report exposure (see Supplementary Table S10). Interestingly, the model revealed no significant difference between high school and university-educated participants in terms of disinformation exposure ($p = .486$). This suggests that the key distinction lies between lower and higher education levels, with high school graduates showing patterns more similar to those with university education (Table S10).

For **susceptibility to trust disinformation**, all three predictors were again significant. Compared to the youngest age group, participants over 55 years were about twice as likely to rate disinformation

Table 2
Means and standard deviations of trust-related measures by education level.

Measure	Elementary (n = 256)	Practical (n = 1008)	High school (n = 1281)	University (n = 695)
Trust in disinformation	0.37 (0.42)	0.44 (0.46)	0.35 (0.41)	0.24 (0.33)
Trust in factual news	0.63 (0.57)	0.63 (0.53)	0.72 (0.54)	0.81 (0.59)
Discernment	0.26 (0.58)	0.20 (0.59)	0.37 (0.61)	0.57 (0.64)

Note. Discernment is computed as the difference between trust in factual news and trust in disinformation. In the full sample, discernment scores ranged from −1.71 to 2.00 (M = 0.35, SD = 0.63).

narratives as trustworthy. Women and participants with lower levels of education also showed significantly higher susceptibility (Supplementary Table S11). We also examined a multivariate model predicting **discernment** (i.e., the difference between trust in factual news and disinformation). The results mirrored the patterns found for susceptibility to trust, but in the opposite direction: younger participants, men, and those with higher education exhibited significantly better discernment (Supplementary Table S12).

For **disinformation sharing**, the strongest predictors were again age and education. Older adults and participants with lower education levels were significantly more likely to report sharing at least one disinformation narrative. Gender was not a significant predictor in this model (Supplementary Table S13).

3.3. Associations between exposure, trust, and sharing

To examine the relationships among the key outcome variables, we computed Spearman correlations between exposure to disinformation and factual news, trust in both types of content, discernment, and the proportion of shared disinformation and news (see Supplementary Table S14 and Fig. 1 for the correlation heatmap).

Exposure to disinformation was positively correlated with both trust in disinformation ($\rho = 0.52$, $p < .001$) and sharing of disinformation ($\rho = 0.31$, $p < .001$), suggesting that individuals who encountered more disinformation narratives were also more likely to trust and share them. Exposure to factual news showed a similar pattern: it was positively related to trust in factual news ($\rho = 0.59$, $p < .001$), to discernment ($\rho = 0.47$, $p < .001$), and also moderately correlated with disinformation exposure ($\rho = 0.38$, $p < .001$). This indicates that individuals who consume political content may encounter both accurate and misleading information, possibly reflecting the blended nature of online information environments.

Trust in disinformation was moderately associated with disinformation sharing ($\rho = 0.38$, $p < .001$), whereas trust in factual news was only weakly related to sharing of factual news ($\rho = 0.18$, $p < .001$). Trust in factual news and disinformation were weakly positively correlated ($\rho = 0.22$, $p < .001$), indicating that trust in one type of content did not imply distrust in the other.

Discernment showed a strong positive correlation with trust in factual news ($\rho = 0.75$, $p < .001$) and a negative one with trust in disinformation ($\rho = -0.39$, $p < .001$), reinforcing its validity as a measure of accuracy in judgment. It was also negatively related to

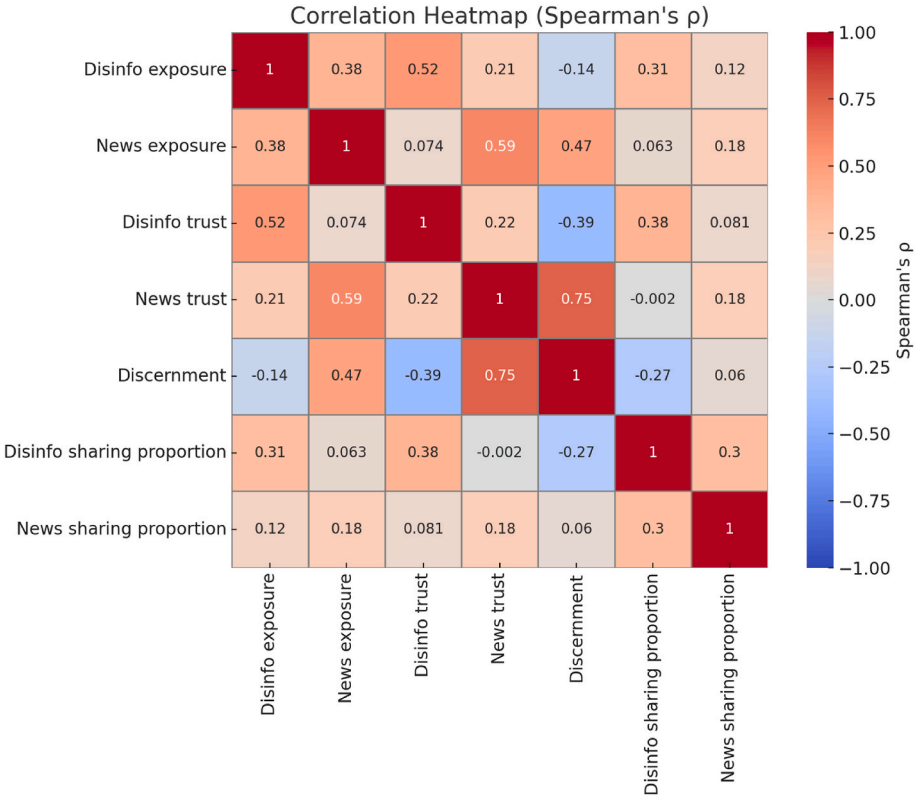


Fig. 1. Spearman correlation heatmap of disinformation-related and news-related variables.
Note. Spearman's ρ values are shown for all pairwise correlations among seven key variables: exposure to disinformation, exposure to factual news, trust in disinformation, trust in factual news, discernment (difference between trust in news and disinformation), proportion of disinformation narratives shared, and proportion of factual news shared. Positive correlations are shown in red, negative in blue, with color intensity reflecting the strength of the relationship. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

disinformation sharing ($\rho = -0.27$, $p < .001$), but only weakly associated with news sharing ($\rho = 0.06$, $p = .007$).

Sharing of factual news was positively related to trust in factual news ($\rho = 0.18$, $p < .001$) and showed a weak positive correlation with trust in disinformation ($\rho = 0.08$, $p < .001$). This pattern suggests that individuals who share factual news do not necessarily avoid disinformation, but rather tend to engage more actively with political content in general. Supporting this interpretation, the correlation between disinformation and factual news sharing proportions was moderate ($\rho = 0.30$, $p < .001$), indicating that those who share one type of content are also more likely to share the other.

3.3.1. *Narrative-level associations between perceived trustworthiness and sharing*

To gain a more granular understanding of the relationship between perceived trustworthiness and sharing, we examined each narrative individually. Using binomial logistic regression models restricted to participants who had been exposed to a given narrative, we tested whether perceived trustworthiness predicted the likelihood of sharing that specific narrative.

We found a consistent pattern for disinformation narratives (A–G): perceived trustworthiness significantly predicted the likelihood of sharing for all of them, with Odds Ratios ranging from 2.16 to 6.70 (all *p*-values <0.01, except for narrative F). In contrast, for factual news narratives (H–J), perceived trustworthiness did not significantly predict sharing behavior, and the Odds Ratios were small and non-significant (ranging from 0.73 to 2.01). Notably, in the case of narrative J, perceived untrustworthiness was even associated with a slightly *higher* probability of sharing, although this effect was not statistically significant. This contrast reinforces earlier findings suggesting that disinformation is more likely to be shared when it is trusted, whereas factual content may be shared for reasons less directly tied to perceived credibility.

Disinformation narratives were not only more influenced by trustworthiness but also shared more frequently in general. For instance, among participants who encountered them, narratives B and C had predicted sharing probabilities of over 20 % when perceived as trustworthy (Fig. 2). In contrast, factual news narratives were shared much less frequently, with maximum predicted probabilities under 10 %, even when they were seen as trustworthy.

We also observed substantial differences in exposure across narratives. While some disinformation narratives (e.g., G and A) were encountered by more than one-third of participants, others (e.g., F and C) were seen by fewer than 12 %. Similarly, exposure to factual news varied widely. These differences highlight the importance of considering both exposure and perceived credibility when analyzing the likelihood of sharing. Full results, including exposure rates, model coefficients, and predicted probabilities, are reported in Supplementary Table S15, along with English translations of the original disinformation narratives.

To further explore the relationship between perceived trustworthiness and sharing behavior, we analyzed cross-tabulations of trust and sharing for each disinformation narrative to determine whether some individuals may have deliberately shared content they did not consider trustworthy. Across all disinformation narratives, the vast majority of those who shared content also rated it as trustworthy. However, a small number of participants (ranging from 6 to 19 individuals per narrative) shared disinformation that they explicitly did not consider trustworthy. For instance, 114 participants shared Narrative B while rating it as trustworthy, compared to only 19 who shared it despite not trusting it.

4. Discussion

The aim of this study was to examine exposure, trust, and sharing behavior related to political disinformation among adults in the Czech Republic—a small democratic country in Central Europe. Exposure, operationalized as prior recognition of disinformation narratives, was positively associated with their perceived trustworthiness, both for disinformation and for factual news. Trust, in turn, was positively linked to disinformation sharing. This association was evident both in aggregate results and at the level of individual narratives: disinformation narratives were 2–7 times more likely to be shared when perceived as trustworthy. In contrast, perceived trustworthiness had no significant effect on the sharing of factual news, which were generally reported as being shared less often.

We also observed positive associations between disinformation and factual news exposure, trust, and sharing. This suggests that individuals who consume political content may encounter both accurate and misleading information, and tend to engage with it actively—regardless of its veracity.

Sociodemographic differences were evident across age, gender, and

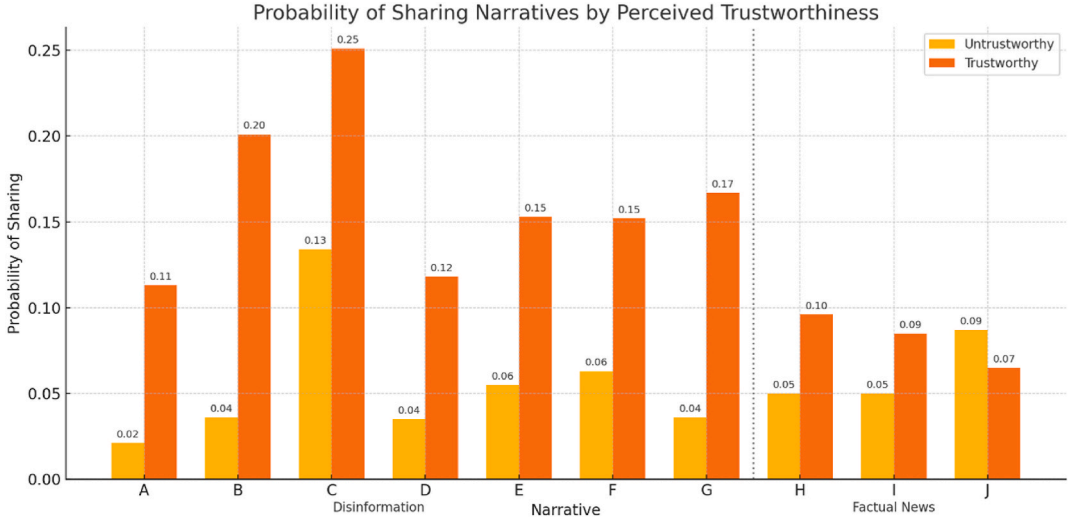


Fig. 2. Predicted probabilities of sharing each narrative, based on perceived trustworthiness.
Note. Grouped bar chart showing model-predicted probabilities of sharing narratives when perceived as untrustworthy (left bar) vs. trustworthy (right bar). Results are based on binomial logistic regressions conducted separately for each narrative, restricted to participants who had been exposed to that narrative. Narratives A–G are disinformation, H–J are factual news. The differences between the two conditions illustrate the extent to which perceived trustworthiness predicts sharing behavior.

education, with each factor contributing uniquely to patterns of exposure, trust, discernment, and sharing. Older adults were more likely to be exposed to political disinformation, to trust it, and to share it. However, when measured as a continuous variable, age was not significantly associated with discernment—the ability to differentiate between true and false content. This may reflect a non-linear relationship: discernment was lowest among participants aged 45–64, and slightly higher in the oldest age group (65+). Gender differences were most pronounced in the domain of trust, with women showing higher susceptibility to trust disinformation and lower discernment scores, despite being less exposed than men. Educational differences were consistent across all outcomes. University-educated participants reported the lowest trust in disinformation, the highest trust in factual news, and the highest discernment. The opposite pattern was observed among participants with practical education. Education was also significantly associated with disinformation sharing: participants with elementary education shared the most, while university-educated participants shared the least. In contrast, the sharing of factual news did not significantly differ by education level. While all three sociodemographic predictors—age, gender, and education—were statistically significant in the multivariate models, the overall explained variance was low ($R^2 < 0.10$ for all models), suggesting that additional psychological or contextual variables (such as political ideology or partisanship) are likely to play a more substantial role in determining who is exposed to, trusts, and shares disinformation.

Our findings are consistent with a growing body of literature suggesting that exposure, trust, and sharing behavior are closely intertwined in the context of political disinformation. The positive association between exposure and perceived trustworthiness (Pennycook et al., 2018) implies that repeated encounters with a narrative may increase its plausibility—a dynamic aligned with the illusory truth effect (Fazio et al., 2015), which in turn increase the probability of sharing (Hopp, 2022), although sharing behavior is sometimes inconsistent with accuracy beliefs due to inattention (Pennycook & Rand, 2021). These findings support the idea that reducing the believability of disinformation through well-targeted interventions may also help curb its dissemination (Roozenbeek et al., 2022)—particularly among so-called "misleaders," who spread false content not with intent to deceive, but because they believe it to be true (French et al., 2024). In addition to undermining belief in false content, interventions should also aim to increase the visibility and perceived social value of sharing accurate information, as trust alone may not be sufficient to prompt users to disseminate reliable news.

Our findings also revealed positive associations between disinformation and factual news exposure, trust, and sharing. This pattern suggests that individuals who encounter and engage with political information online do not necessarily do so selectively. Rather than supporting the idea of ideological echo chambers or selective exposure to disinformation, our results align with emerging evidence that heavy consumers and sharers of political content often engage with both reliable and unreliable information (Baribi-Bartov et al., 2024). This challenges the prevailing narrative that disinformation spread is primarily driven by partisan media preferences or filter bubbles (Kim et al., 2021), and instead points toward more generalized patterns of high-volume, low-discrimination engagement (Pennycook & Rand, 2021). Understanding this behavioral tendency may be critical for designing interventions that not only address belief accuracy but also promote more deliberate and discerning engagement with political content.

Finally, we observed meaningful sociodemographic patterns in disinformation vulnerability. In line with prior research (Chen et al., 2023), older participants were more likely to be exposed to disinformation, trust it, and share it. However, the association between age and discernment—the ability to distinguish between true and false content—was less straightforward. While no linear relationship was found, a U-shaped pattern emerged, with the lowest discernment observed around midlife (ages 45–64), and slightly higher scores among the oldest participants. This partially aligns with findings from Sultan et al. (2024), who reported higher accuracy among older adults in a recent meta-analysis based on U.S. data (Sultan et al., 2024). Education showed the expected effects: participants with lower educational attainment were more vulnerable to trusting and sharing disinformation, and scored lower on discernment (Baptista & Gradim, 2020; Chen et al., 2023; Schaewitz et al., 2020; Wolverton & Stevens, 2019). Notably, while elementary and practical education were consistently associated with higher exposure, trust, and sharing, individuals with high school education did not significantly differ from university graduates in terms of exposure. This may reflect a threshold effect, whereby exposure risk increases more sharply among those with the lowest levels of formal education. Although our study did not directly assess cognitive ability, recent evidence suggests that it plays a relevant, though complex, role in disinformation susceptibility. A meta-analysis by Sultan et al. (2024) found that higher analytical thinking, as measured by the Cognitive Reflection Test, was associated with better accuracy in distinguishing true from false headlines—but also with a tendency toward greater overall skepticism (i.e., a false-news bias) (Sultan et al., 2024). Additionally, as Wineburg and McGrew (2019) demonstrated, even highly educated individuals may struggle to assess credibility online unless they employ strategies such as lateral reading (Wineburg & McGrew, 2019). However, as Breakstone et al. (2022) showed, these strategies were still rarely adopted in practice at that time and were seldom integrated into university curricula or student support materials (Breakstone et al., 2022). Interventions aiming to improve resilience should therefore focus not only on boosting education or critical thinking in general, but also on promoting specific evaluative skills that help individuals navigate digital information environments.

The most striking patterns, however, emerged in relation to gender. Women in our sample were less exposed to political narratives overall, yet rated disinformation as more trustworthy and factual news as less trustworthy than men—resulting in markedly lower discernment scores. This suggests that lower exposure may be linked to reduced familiarity with political content, and thus a weaker ability to assess its credibility. Previous research has shown that political interest and active engagement are key protective factors against disinformation (Buchanan, 2020). Women may be less likely to view themselves as politically engaged or confident in evaluating such content—making them potentially more susceptible to emotionally resonant or ambiguous disinformation narratives.

4.1. Strengths and limitations

A key strength of our study lies in the use of authentic disinformation narratives rather than artificially constructed items. These were presented in a neutral format and shown alongside factual news, which likely reduced social desirability bias and participants' reluctance to report trust or sharing of disinformation. While this design does not fully replicate the context in which people typically encounter online content, it offers a compromise between ecological realism and the need for standardized exposure across participants. By focusing specifically on political disinformation—arguably one of the most socially consequential forms of false content—we addressed a highly relevant and timely topic.

Our study assessed three core dimensions of disinformation engagement: exposure, trust, and sharing. This allowed us to provide a more comprehensive picture of how individuals interact with false information, in contrast to many previous studies that focus on just one of these dimensions. Moreover, our data were drawn from a representative sample of the adult population in the Czech Republic, which helps minimize sampling bias and supports the generalizability of our findings.

Nevertheless, several limitations must be acknowledged. First, our design omitted source attribution for all narratives. This decision was made to reduce confounding influences related to institutional trust and

source familiarity (Sultan et al., 2024). While this may have limited ecological validity—since most real-world content includes sources—it reflects the reality of how disinformation is frequently encountered online, often without visible cues to origin (e.g., screenshots, decontextualized reposts; see (Chen et al., 2023). Future research should consider systematically capturing participants' memory for source and prior familiarity, as both may influence credibility judgments and sharing intentions.

Second, although our set of narratives was carefully selected by media experts, it may still reflect editorial choices that limit generalizability. Some narratives may not have been widely encountered, while others may resemble different but thematically similar content. Relatedly, exposure was assessed through self-report, which is subject to recall bias and potential over- or under-estimation of prior encounters. Furthermore, although narratives were selected based on their prominence in the Czech disinformation landscape, we did not systematically balance them across ideological perspectives (e.g., progressive vs. conservative). Future research should explore the potential effects of partisan framing and assess whether political alignment influences trust and sharing behavior.

Third, the imbalance in the number of disinformation (seven) and factual news narratives (three) may have impacted the comparison of trust and sharing across content types. We chose to present more disinformation items to better capture variability in individual responses, given that this was our main focus. However, we recognize that this design choice may have unintentionally primed participants toward greater skepticism, as noted in prior literature. Future studies should aim to balance narrative types more closely, or at least test for potential framing effects.

Fourth, we focused exclusively on text-based content. Multimodal disinformation—such as memes or videos—is increasingly prevalent and may influence perceived credibility differently than text (Hameleers et al., 2020; Lee et al., 2023). Future studies should explore whether our findings replicate across formats.

Fifth, although our total sample was relatively large, some key behaviors—particularly the sharing of disinformation—remained low in absolute terms. This limited our ability to conduct subgroup analyses (e.g., within age × education strata) or to examine less common but potentially meaningful patterns (e.g., frequent sharers). We recommend that future studies include oversampling of such groups or adopt preregistered designs with sufficient power to address these effects.

Finally, our study was primarily exploratory. Although our analyses were informed by prior research and theory, we did not preregister specific hypotheses. The observed associations—particularly those involving sociodemographic variables—should therefore be interpreted with caution and confirmed in future confirmatory studies. We encourage researchers to pre-specify and test subgroup-specific effects, particularly those involving age, gender, and education, which emerged as consistent predictors in our data.

5. Conclusions

Our findings offer important insights into the dynamics of political disinformation in the Czech Republic. We show that exposure, trust, and sharing are closely interrelated, and that trust is a key driver of disinformation dissemination. While disinformation is more likely to be shared when perceived as trustworthy, this link does not hold for factual content, which is generally shared less. Sociodemographic differences suggest that older adults and individuals with lower education levels are more vulnerable to disinformation. Most strikingly, however, women in our sample were less exposed to political narratives overall but were more likely to trust disinformation and showed lower discernment than men.

These findings have direct implications for targeted interventions. One promising pathway to strengthen resilience among under-engaged groups—such as women in our study—could involve boosting political interest and perceived self-efficacy in evaluating information. As noted by Kozyreva et al. (2024), certain individual-level interventions may be particularly well-suited for this purpose. These include interactive and gamified prebunking tools, digital literacy boosters, and tailored media education programs that can build cognitive resistance in accessible and engaging ways (Kozyreva et al., 2024). If designed with specific audiences in mind, such interventions may not only improve critical evaluation skills, but also foster greater motivation to engage with trustworthy political content in the first place.

Future research should explore how these strategies work in different sociocultural contexts and among diverse population groups. Understanding which combinations of content, format, and delivery mechanisms are most effective in increasing resilience to disinformation remains a key challenge for both researchers and policymakers.

During the preparation of this work, the authors used ChatGPT (OpenAI, GPT-4) to assist with language editing and revision support. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

CRediT authorship contribution statement

K. Lukavská: Writing – review & editing, Writing – original draft, Validation, Software, Investigation, Formal analysis. **R. Gabrhelík:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Conceptualization. **M. Miovský:** Validation, Resources, Methodology, Investigation, Conceptualization. **N. Hynek:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization. **B. Gavurová:** Writing – review & editing. **L. Šťastná:** Writing – review & editing. **M. Barták:** Writing – review & editing, Data curation. **B. Petruželka:** Writing – review & editing, Data curation. **V. Moravec:** Writing – review & editing, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chbr.2025.100686.

Data availability

Data will be made available on request.

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