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Ideological symmetry in out-group bias: a neuroimaging study in the context of vaccine hesitancy

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One of the most contentious debates in political psychology relates to the existence of ideological (a)symmetry in out-group bias. Recent neuroimaging and psychological studies circumvented previous criticisms regarding the inclusion of ideologically biased out-groups by directly targeting the ideological out-groups themselves (rightists for leftists and leftists for rightists). Their findings confirmed the asymmetry claim, with particularly robust and informative results at the neural level. Nevertheless, the recent pandemic provided a new opportunity for the investigation of ideological (a)symmetry in out-group bias by introducing an ideologically neutral yet highly discriminated and stigmatized group—vaccine-hesitant individuals. In this preregistered study, 50 Finnish adults were scanned using magnetoencephalography to delineate function-specific neural mechanisms of bias against vaccine hesitancy. The results show a clear neural bias against vaccine hesitancy regardless of political inclination. The findings reported here contribute to the present debate by selecting a unique ideologically neutral target and revealing that ideological (a)symmetries in out-group bias are highly context-dependent.

KEYWORDS

political neuroscience, ideological symmetry, out-group bias, neural oscillations, vaccine hesitancy

Introduction

This study focuses on the debated ideological differences in out-group bias between political leftists and rightists (Baron and Jost, 2019; Ditto et al., 2019). Psychological research claims that rightists value in-group loyalty (Graham et al., 2012), perceive more threats from out-groups (Stewart and Morris, 2021), and have stronger disgust reactions (Inbar et al., 2009; Oxley et al., 2008). These asymmetrical differences have been linked to biology (Oxley et al., 2008), including neurophysiology (Ryan, 2020; Smith et al., 2011; Zebarjadi et al., 2023). Research on ideological asymmetry has been criticized for target-group bias, among other things. The supporters of a more symmetrical view toward political groups argue that all individuals often tend to have negative-valenced feelings toward dissimilar others (Crawford and Pilanski, 2014), and the impression about rightists being more prejudiced about out-groups is created by a consistent skew in the choice of the specific groups (left-wing low-status minorities) researched (Crawford and Brandt, 2020; Stern and Crawford, 2021). Additionally, some earlier biological asymmetrical findings have not been replicated (Bakker et al., 2020).

Yet two recent studies (Hasson et al., 2018; Kluge et al., 2024) used the opposing political camp itself as a target for each sampled political group, thus bypassing the target-group skew, and still observed ideological asymmetry in out-group bias among samples from multiple nations. The latter study used neuroimaging and followed a robust methodology to evaluate intergroup bias using sustained alpha–beta responses (Hautala et al., 2022; Kluge et al., 2024; Levy et al., 2021, 2022) during the Implicit Association Test (IAT; Greenwald et al., 2003). More specifically, early (100–500 ms) alpha suppression in the incongruent trials compared to congruent trials seems to reflect automatically biased perceptions in the right lingual gyrus (Levy et al., 2021), and control for automatic prejudice in the anterior cingulate cortex (Kluge et al., 2024). Later (700–1,400 ms) beta suppression is thought to reflect decision-making and motor control processes in the motor cortex (Kluge et al., 2024; Levy et al., 2021). Whether these findings can be generalized to other contexts and balanced or neutral target groups remains to be clarified.

In the present study, we implemented a similar methodology and scanned participants using magnetoencephalography (MEG) while they completed the IAT (Greenwald et al., 2003) to investigate ideological asymmetries in out-group bias against an ideologically neutral out-group: vaccine-hesitant individuals (Stoeckel et al., 2022). The increase in vaccine hesitancy is an urgent threat to global health, which was especially pronounced during the COVID-19 pandemic (Borin et al., 2024). This movement is part of a growing distrust in governments, technology, and science (Borin et al., 2024). While vaccine hesitancy is associated with partisanship in the United States (Cao et al., 2022), it has not been the case in Europe, where vaccine hesitancy is strongly tied to the rise of political populism instead of the ideological left–right dimension (Kennedy, 2019; Stoeckel et al., 2022). In this study, we investigate vaccine-supporting individuals, thus excluding populist beliefs and making it possible to investigate the ideological symmetries of the remaining population.

Vaccine-hesitant individuals are highly discriminated against and stigmatized by the general population, as shown in a recent neuroimaging study (Hautala et al., 2022). The present study aims to investigate whether the bias against this predominantly ideologically neutral outgroup is ideologically symmetrical. We hypothesize that political ideology would explain differences in bias against vaccine hesitancy (see hypothesis 5 in https://osf.io/uwmpa/?view_only=e48e1c57ad8f4639ba35a974b92122aa).

Methods

The study was preregistered (see https://osf.io/uwmpa/?view_only=e48e1c57ad8f4639ba35a974b92122aa) and reviewed and approved by the Aalto University Research Ethics Committee. The participants provided written informed consent to participate in this study.

Participants

After explicitly consenting, 121 healthy adults participated in the study. Participants were native Finns, compatible with MEG, had no acute psychiatric or neurological disorders, and displayed at least moderate negativity against vaccine opposers (scored at least four out of seven on the self-reported negativity scale of the screening survey).

As the preregistration had multiple hypotheses, our main emphasis in recruitment was not on political balance, which resulted in a skewed sample given the strong left bias among the young adults, similar to a previous paper (Hautala et al., 2022): 61% of the full sample reported being politically leftist and only 24% rightist. During the end phase of our data acquisition, the political division was more equal; thus, we used only the last 50 recruited participants to test the political asymmetry hypothesis ($N = 50$).

This sample is regarded as large for a neuroimaging study (typically $N = 10$–25; Baldauf and Desimone, 2014; Chaumon et al., 2021; Hautala et al., 2022; Levy et al., 2016; Zebarjadi et al., 2023). This pool consisted of 62% women, with ages ranging from 19.2 to 57.5 years (median age: 25.2). It included 46% leftists, 34% rightists, and 20% centrists. Political inclination was self-reported on a 1–5 scale from extremely leftist to extremely rightist. The level of political extremity did not differ between leftists and rightists [$t_{(38)} = -1.240$, $p = 0.223$].

Instruments

In this study, intergroup bias is measured on three levels: IAT score, neural marker, and explicit negativity. To create the neural marker of intergroup bias, the participants completed the IAT (Greenwald et al., 2003; Greenwald and Lai, 2020) while their neural magnetic activity was recorded using a MEG. We calculated their IAT score and the neural marker using a robust pipeline from earlier studies (Hautala et al., 2022; Kluge et al., 2024; Levy et al., 2021). Before the MEG measurement, participants reported their attitudes toward vaccine hesitancy in an online survey.

IAT

The IAT paradigm was exactly as described by Hautala et al. (2022). We used 10 separate stimulus items that were repeated multiple times in the test blocks for each of the four categories: positive words (e.g., joy and smile), negative words (e.g., sadness and death), vaccine-opposing pictures (e.g., a person with a poster "NO to vaccines" and multiple people on an anti-vaccines parade), and vaccine-supporting pictures (e.g., a person getting a vaccine and a Facebook profile picture with the frame "I am vaccinated"). There were eight practice (6–8 trials in each) and two test blocks (100 trials in both), with the test blocks taking up 78% of the experiment and used for analysis. The order of stimuli inside a block was randomized. The order of congruent/incongruent blocks was counterbalanced across participants, meaning that half of the participants first saw categories in congruent mapping and half saw categories in incongruent mapping. The test lasted ~10 min, including breaks. The IAT scores were used as implicit polarization markers and calculated using D scoring (Greenwald et al., 2003). For that, we calculated the average response times for both

incongruent and congruent association conditions, with error trials included as 600 ms added to the mean time of correct responses in that condition. Then, D scores were calculated by finding the difference in the average response times between conditions and dividing the difference score by a pooled standard deviation of both blocks.

Neural marker of bias

During the IAT, continuous rhythmic neural activity was recorded with a whole-head 306-channel neuro-magnetometer (VectorView, Elekta-Neuromag, Helsinki, Finland) of the MEG Core of Aalto NeuroImaging infrastructure at Aalto University. The neural data were cleaned using MNE-Python (Gramfort, 2013)—Maxfilter, independent component analysis, and epoching—and MATLAB 2023B (The MathWorks Inc, 2023) with Fieldtrip (Oostenveld et al., 2011)—visual trial rejection. The rest of the analysis was performed in MATLAB. Trial events were detected by aligning the data from test blocks with stimulus onsets; trials with button press errors and response times shorter than 300 ms or longer than 3,000 ms were discarded from the analysis as conventionally recommended in the IAT guidelines (Greenwald et al., 2003). Time-frequency representations (TFRs) of power were computed by applying the fast Fourier transform (FFT) for short sliding time windows, with power estimates averaged across tapers. For the 1- to 40-Hz frequency range, a Hanning taper was applied to each epoch of the sensor data, resulting in the FFT having a temporal resolution of 50 ms and a spectral resolution of 1 Hz. We obtained induced activity by subtracting evoked components' power from oscillatory power. We examined TFRs of the contrasts between the incongruent and congruent conditions of identical stimuli during the IAT. We used a non-parametrical randomization procedure to obtain corrections for multiple comparisons (Maris and Oostenveld, 2007) for the TFRs. The details of that approach have been elaborated in publications following a similar process (Levy et al., 2018, 2019). We calculated sensor-level neural markers by choosing the time-frequency window with the highest suppression and calculating neural suppression ratios (incongruent–congruent power level difference divided by congruent condition power level) using these restricted windows. The scripts used for the MEG analysis are available at https://version.aalto.fi/gitlab/klugea1/vax_intervention/.

Explicit attitudes

Before the MEG measurement, participants reported their attitudes toward vaccine hesitancy in an online survey. The survey questions are reported in the preregistration (https://osf.io/uwmpa/?view_only=e48e1c57ad8f4639ba35a974b92122aa). Because of the relatively small sample size, we focus here on the neural results and only include the self-reported negativity against vaccine hesitancy as an explicit measure.

The negativity scale is the same as used in Hautala et al. (2022) and includes seven items, on a 1–7 scale, with 1 being "totally disagree" and 7 being "totally agree." The items included (1) "I trust the vaccine[']s ability to improve our health"; (2) "I feel anger toward people who refuse to get vaccinated against corona without a medical reason"; (3) "I feel that the people refusing to get the corona-vaccine are downplaying the seriousness of the disease"; (4) "I think the people refusing to get corona-vaccines without a medical reason are selfish"; (5) "I feel positively toward people who have gotten vaccinated against the coronavirus"; (6) "I think the vaccination passport is fair"; and (7) "We should make people get vaccinated against coronavirus using whatever means necessary, if they do not have a medical reason to refuse" (Hautala et al., 2022). The negativity score was calculated as an average across items.

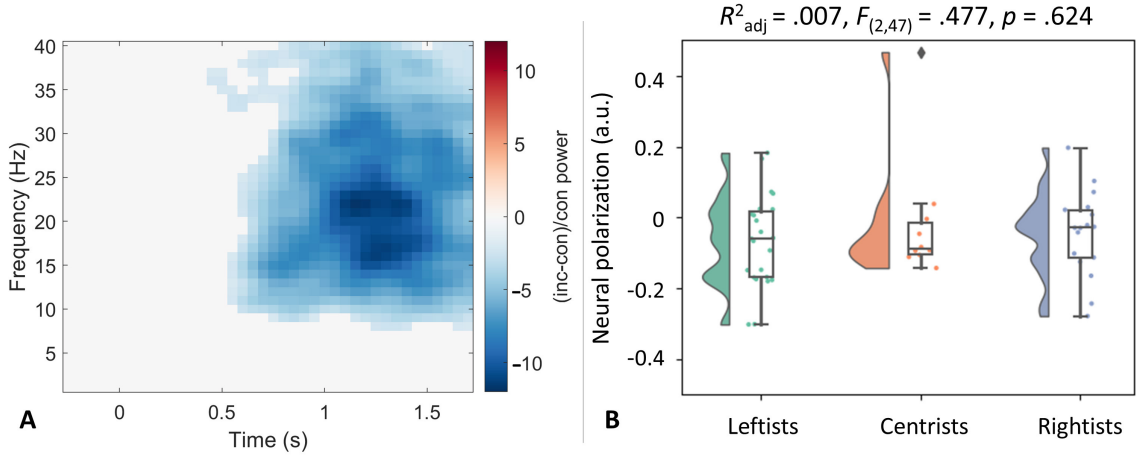

FIGURE 1
Neural bias. **(A)** Beta suppression in the incongruent-congruent contrast of the Implicit Association Test. The peak of the suppression was 19Hz at 1.25 s post-stimulus onset. **(B)** Ideological symmetry of the neural bias extracted from **(A)**. There were no group differences between leftists, centrists, and rightists.

Statistical analysis

We employed IBM SPSS Statistics 29 (IBM Corp, 2023) for statistical analyses. We used univariate analysis of variance (ANOVA) and a linear mixed effects (LME) model to compare samples across political ideologies. A sensitivity analysis in G*Power (Faul et al., 2007) as recommended by Giner-Sorolla et al. (2024) revealed that the sample was big enough to detect effect sizes >0.45 with 80% power. We tested for correlations using Pearson's correlation coefficient. We used Raincloud for plotting (Allen et al., 2021).

Results

We tested whether out-group bias measures (neural marker, IAT score, and self-reported negativity) against vaccine hesitancy would be related to political inclination.

First, we calculated the neural marker as a power ratio from the peak suppression in the incongruent–congruent IAT condition contrast. The suppression peaked at 19 Hz 1.25 s post-stimulus onset, and we used the effect window around this peak (±2 time and frequency slots, so 1.15–1.35 s, 17–21Hz; Figure 1A).

We ran a univariate ANOVA between leftists ($N = 23$), centrists ($N = 10$), and rightists ($N = 17$) and found no differences in their neural bias, $R^2_{adj} = -0.022$, $F_{(2,47)} = 0.477$, $p = 0.624$ (Figure 1B). Despite the relatively small sample size for behavioral measures, we ran the same tests for IAT scores, $R^2_{adj} = -0.027$, $F_{(2,47)} = 0.360$, $p = 0.699$, and self-reported negative attitudes, $R^2_{adj} = 0.000$, $F_{(2,47)} = 1.000$, $p = 0.375$, and found no effect of political ideology on those additional measures of bias. To further validate our results, we ran an LME model to determine whether the neural marker of bias depends on the political group (fixed variable) or individual differences in implicit (IAT score) or explicit (negativity) behavioral bias (covariance parameters). We obtained results similar to those from the ANOVA: $R^2_{pseudo} = -0.020$, $F_{(2,47)} = 0.477$, $p = 0.624$. Thus, we were not able to reject the null hypothesis of political symmetry.

Because political orientation is a spectrum, we checked whether the out-group bias measures would depend on the self-reported political inclination on a 1–5 scale. We found that neither the neural marker ($R = 0.116$, $p = 0.424$), IAT scores ($R = -0.065$, $p = 0.656$), nor negativity ($R = -0.207$, $p = 0.149$) were dependent on political inclination. Thus, our analysis showed no relation between political inclination and bias against vaccine opposers on any level.

We additionally checked for asymmetry in the politically imbalanced full sample (74 leftists, 18 centrists, and 29 rightists) and found no differences for the neural marker of bias, $R^2_{adj} = -0.012$, $F_{(2,118)} = 0.278$, $p = 0.758$; IAT scores, $R^2_{adj} = 0.010$, $F_{(2,118)} = 1.586$, $p = 0.209$; and negativity, $R^2_{adj} = 0.007$, $F_{(2,118)} = 1.430$, $p = 0.243$.

Discussion

Our analysis did not find ideological asymmetry in negative views against vaccine hesitancy at any of the three levels of investigation, contrasting the earlier findings of asymmetry (Hasson et al., 2018; Kluge et al., 2024) targeting the partisan political groups. A study investigating attitudes toward different groups in Finland found that young Finnish adults are most biased against groups typically regarded as living a life deviating from the norm (Koirikivi et al., 2023). Vaccine-hesitant individuals can be viewed as one such group, as the vast majority of people in Finland took the COVID-19 vaccine during the pandemic, making vaccine hesitancy a clear deviation from the norm. However, Koirikivi et al. (2023) did not investigate ideological asymmetry, but our study results further clarify their conclusions and add that this out-group bias does not differ across political camps.

Thus, the present study addressed the highly debated question of asymmetry (Altemeyer, 1981; Duckitt, 2001; Hasson et al., 2018; Hodson and Busseri, 2012; Jost, 2017; Sibley and Duckitt, 2008) or symmetry (Bakker et al., 2020; Brandt, 2017; Brandt et al., 2014; Brandt and Crawford, 2020; Chambers et al., 2013; Wetherell et al., 2013) in out-group bias. By relying on an emerging neuroimaging methodology to measure out-group bias and a recently created new out-group that is highly stigmatized and discriminated yet ideologically neutral, we show that ideological out-group bias is largely context-dependent, and the question of symmetry cannot be answered simplistically or monolithically.

Accommodating neuroimaging and behavioral differences in sample sizes remains challenging. As is often the case with neuroimaging studies (Baldauf and Desimone, 2014; Chaumon et al., 2021; Hautala et al., 2022; Levy et al., 2016; Zebarjadi et al., 2023), the sample size in this study is diminutive compared to behavioral psychological studies investigating similar topics due to technical and financial constraints but is considered appropriate for an MEG study (Chaumon et al., 2021). Additionally, MEG studies rely not only on the number of participants but also on the condition trials, which are typically set to 50 in MEG studies (Chaumon et al., 2021). In this study, we used 100 trials per condition to increase the statistical power and reliability. Future neuroimaging research would benefit from employing more diverse samples to validate the findings reported here and further explore the nuances of ideological symmetry in out-group bias.

Data availability statement

As MEG data cannot be fully anonymized, it cannot be made publicly available by Finnish data protection laws. The individual behavioral data cannot be shared following the ethics permit behind this submission and GDPR. Data can however be shared with scientific collaborators after an amendment to the research ethics permit via Aalto University's ethics committee and a data transfer agreement.

Ethics statement

The studies involving humans were approved by Aalto University Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AK: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft. JL: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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