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Asymmetry in political polarization at multiple levels of bias

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Abstract
While some studies show ideological asymmetry in outgroup bias between rightists and leftists, those studies often target an ideologically biased outgroup. Here, we bypass this issue by targeting the ideological outgroups (rightists for leftists, and leftists for rightists). We rely on a magnetoencephalography-based approach delineating function-specific neural mechanisms to test for ideological asymmetries at multiple levels: explicit psychological self-reports, implicit behavioral bias, and neural oscillations. Using a computational model balancing the stimuli and screening 81 rightists and leftist Israeli individuals, we find ideological asymmetry with rightists being more biased at all three levels. Furthermore, the neural results add important insights by uncovering two underlying mechanisms: The first (late beta-band motor activity) is strongly associated with implicit behavior, while the second (early alpha-band dorsal anterior cingulate activity) reveal an antileftist bias for both groups. We discuss implications of the findings on bias, ideological asymmetry, their neural underpinnings, and social norms.

KEYWORDS
ideological asymmetry, neuro-politics, political neuroscience, political polarization, political psychology, social neuroscience

Annika Kluge and Eliyahu Adler contributed equally and share first-authorship.

INTRODUCTION

In the center of this study is the debate about ideological differences in outgroup bias (Baron & Jost, 2019; Ditto et al., 2019). Research claims that ideologically rightists identify more with their social group (Graham et al., 2012; Stewart & Morris, 2021), perceive more threat from outgroups, and have stronger fear and disgust reactions (Inbar et al., 2009; Oxley et al., 2008). Neuropolitical studies have also found differences in the structure and function of ideologically leftist and rightist brains. For example, studies using structural and functional magnetic resonance imaging (MRI and fMRI) attribute a larger (Nam, 2020; Nam et al., 2018) amygdala to rightists and have reported greater activation in it compared to leftists in response to threatening stimuli (Schreiber et al., 2013). In addition, fMRI and electroencephalography (EEG) studies consistently report leftists showing more activation in anterior cingulate cortex (ACC) (Amodio et al., 2007; Haas et al., 2017, 2020; Jost, 2021) in incongruent situations, possibly reflecting higher sensitivity to monitoring conflict and better control in dealing with new information (Amodio et al., 2007; Jost & Amodio, 2012).

In contrast, some recent studies question ideological psychophysiological asymmetry in threat perception and negativity bias (Bakker et al., 2020; Fournier et al., 2020; Johnston & Madson, 2022) and argue that all individuals have negatively valenced feelings against dissimilar others (Crawford & Pilanski, 2014), and the impression about rightists being more biased is created by the choice of the researched groups, namely, low-status minorities (Crawford & Brandt, 2020). Indeed, studies have found that leftists and rightists express discrimination (Wetherell et al., 2013), prejudice (Chambers et al., 2013), and intolerance (Brandt et al., 2014) mediated by perceived threat (Crawford & Pilanski, 2014) symmetrically towards political outgroups. Then again, a recent review concluded that system-justifying motives contribute to asymmetrical political polarization (Jost et al., 2022). Yet, all these studies relied on explicit self-reports in their evaluations, and the symmetry of outgroup bias remains debated (Baron & Jost, 2019; Ditto et al., 2019).

Also in Israel, self-report studies have found that even though leftists are more motivated to feel positively towards political outgroups (Hasson et al., 2018; Porat et al., 2016), the political poles do not differ in empathic reactions or willingness to help (Hasson et al., 2018). Further, they both symmetrically display less empathy towards the political outgroup than their ingroup (Hasson et al., 2018). Accordingly, partisan polarization (i.e., bias between the two poles themselves) in Israel has been on the rise (Orian Harel et al., 2020) since 2009 (Gidron et al., 2022), as it has been also globally (McCoy et al., 2018; Somer & McCoy, 2018). Lately partisan polarization has risen to such a level in Israel that people see it as the most acute cleavage in society (Bassan-Nygate & Weiss, 2020). The unstable coalitions have resulted in five parliament elections in the last 4 years (Gidron et al., 2022). Still, to our knowledge, to date there has not been any multimethod investigation, involving both objective (e.g., neural) and subjective (e.g., self-reports) evaluation of symmetry in the bias that the two poles hold against each other (i.e., polarization) globally (for review, see Iyengar et al., 2019), nor in the Israeli political climate.

There was one neuroscientific study in 2006 in the United States that mapped activations in multiple brain regions involved in cognitive control in the context of affective polarization using fMRI (Knutson et al., 2006). They found amygdala and fusiform gyrus activation during face processing, frontopolar activation correlating with implicit bias, and a correlation of lateral prefrontal cortex (PFC) activation and party affiliation strength. Thus, they suggested the idea that there are two distinct but interactive networks, one more rapid and emotional, and the other more deliberative and factual, co-operating, when processing political information (Knutson et al., 2006). However, besides the correlation of lateral PFC and the political affiliation, the question of symmetry was not addressed.

Compared to self-reports (Theodoridis, 2017), the IAT has repeatedly demonstrated high reliability in measuring implicit bias (Kurdi et al., 2019), although it is debated what the IAT effect actually reflects (Blanton et al., 2009; Oswald et al., 2015). Several fMRI and EEG studies have tried to pinpoint the neural mechanisms behind implicit associations (Forbes et al., 2012; Luo et al., 2006) and mostly reported the relationship between amygdala activation and the behavioral IAT index (Cikara & Van Bavel, 2014; Cunningham et al., 2004), especially in relation to race. However, to our knowledge, ideological affective polarization is underrepresented in such research. More recently, several EEG and MEG studies found that the neural underpinnings of IAT can unravel important insights that implicit and explicit measures have overlooked thus far: Schiller and colleagues (2016) showed the quantitative nature of mental processes during intergroup bias, and Levy et al. discovered that different psychological interventions can reduce outgroup bias in two different social contexts (Hautala et al., 2022; Levy et al., 2021). These studies revealed (1) two neural mechanisms that account for implicit bias, one early perceptual and the second late and cognitive-control related (Levy et al., 2021; Schiller et al., 2016), and additionally, (2) predicting real-life intergroup behavior (Levy et al., 2021). More specifically, the first neural component is based on the occipital cortex (Schiller et al., 2016) and reflects perceptual intergroup bias (Amodio & Cikara, 2021). The second, anterior cingulate cortex (ACC) based component has been interpreted as related to cognitive control of automatic bias (Amodio & Cikara, 2021; Levy et al., 2021; Schiller et al., 2016). As already mentioned, the functioning of ACC has been consistently found to differ between leftists and rightists. Thus, this methodology has potential to precisely and objectively unravel possible ideological asymmetries in outgroup bias, but it has not yet been done.

Therefore, in this study, relying on the MEG neuroimaging-based IAT approach, we investigate whether the self-report, behavioral (i.e., via response-time and error evaluation) and neural determinants of outgroup bias reveal ideological asymmetries between leftists and rightists in Israel to provide a thorough psychophysiological multimethod analysis using balanced stimuli and filling this gap in the literature. By recording neural oscillatory activity during the IAT in 81 Israelis, we hypothesize that (1) rightists are more biased against the outgroup on all three levels, and (2) there are two neural mechanisms accounting for implicit bias, one perceptual and one cognitive control related. We reason this study to advance knowledge on ideological asymmetry, as neural oscillations not only examine the neural underpinnings of ideological outgroup bias but also reveal covert subprocesses that may have been thus far overlooked by self-reported and behavioral measures.

METHODS

Study goals and data analysis design

The goal of this study is to find out whether the self-report, behavioral and neural determinants of outgroup bias reveal ideological asymmetries. The participants undergo MEG screening while performing the IAT. The data is analyzed for the two political sides separately and compared to assess ideological asymmetry. The relationships between different levels of data are tested via correlation analysis. On self-report level, average scores of the intolerance scale are compared. Behavioral data is assessed via *D* scores as commonly suggested for IAT (Greenwald et al., 2003). Neural data determinants are investigated by contrasting the time-frequency representations (TFR-s) of neural oscillations during incongruent and congruent conditions of IAT (Levy et al., 2021). Following the findings of earlier research (Levy et al., 2021) for neural reflectors of implicit bias, we focus on inspecting alpha range (8–12 Hz) neural oscillations in the time window of 100–500 ms post stimulus onset, thereby excluding preperception, premotor, and motor activity.

Participants

A priori power analysis was conducted based on a previous study that examined the neural implicit bias response (Levy et al., 2021) with a Cohen's *d* effect size = .70. The power analysis indicated that a sample size of 24 would be sufficient to detect this targeted neural response at 95% power. Considering that there is no prior study in the same context and that we have two separate political groups to screen, we oversampled and recruited 81 healthy Israeli adults with differing political inclinations. Participants were a heterogeneous sample from various locations in Israel. They were right-handed with no medical, neurological, or psychiatric conditions and were all MEG-compatible (i.e., mainly metal free). Two participants failed to complete data acquisition and two additional participants were excluded later: one due to not completing the MEG paradigm and one due to extremely noisy data. This resulted in a cohort of 77 participants, 45.45% politically rightist, 14.29% centrist, and 54.55% males, ranging in age from 18 to 35 years ($M \pm SD$, 25.42 ± 3.97). We asked the participants to evaluate their political inclination from left to right on a scale of 1–7 (1 meaning *extreme right* and 7 meaning *extreme left*). Participants who reported themselves being centrist (4 on the political inclination scale) were only included in the full group analysis and not included in the comparison of the political groups. For the full group analysis, the centrists were divided into leftists and rightists (meaning, their data were labeled as congruent and incongruent) based on their self-reported consumption of leftist and rightist media. To be able to further interpret the effects in the two political groups, we controlled for their similarity on the level of political extremity. To do that, we brought the rightist (1–3) and leftist (7–5) self-reported political stances to the same scale (1–3) where 1 is extreme and 3 is moderate. The average score of the rightist group ($N = 35$) was 2.17 ± .51, and the average score of the leftist group ($N = 31$) was 2.29 ± .53. There was no statistically significant difference ($p = .358$, $t(64) = -.93$, Cohen's $d = -.228$) between the groups. The study received approval from the institutional Ethics Committee, and participants gave written informed consent before the experiment. The participants were informed that they can leave at any point during each session or drop out of the study and received monetary compensation for their participation.

Explicit measures

Participants were asked to complete a questionnaire to evaluate their political tolerance (Gibson & Bingham, 1982) scale that assessed how much people thought the other political side should be silenced (four-item 7-point Likert-type scale ranging from *strongly disagree* to *strongly agree*). The average score of the scale was calculated across items. Explicit measures were collected before implicit considering their relatively moderate nature to minimize possible intermeasure influences.

IAT neuroimaging stimuli

Participants completed the IAT (Greenwald & Lai, 2020) while lying down in the MEG scanner in a dimly lit room. Stimuli were generated using the E-prime software (Psychology Software Tools Inc.) and presented through a mirror on an LCD monitor placed on a viewing distance of 50 cm. The words were presented on a black background in the center of the screen foveally (horizontal visual angle <2.5°). A photosensitive diode on the screen recorded the onset time of visual stimuli. Stimuli were 20 frequent words with a positive (e.g., peace, health, love) or negative (e.g., horror, terrible, murderous) valence (length: 3–7 letters; usage frequency 2–50 per million [Velan et al., 2005]), and 20 words associated with rightist and leftist politics (length: 3–12 letters). The political stimuli included party leaders (e.g., Bibi, Rabin), media outlets (e.g., Israel Ha'yom, Ha'aretz), political parties (e.g., Benet, Meretz), social organizations (e.g., Hilltop youth, New Israel Fund), and concepts clearly associated with each one of the two ideologies. The words were intentionally preconceived to conceptually balance them (e.g., two party leaders, one news outlet mentioned for both groups), verified by several researchers.

We additionally validated the use of the leftist and rightist words using a computational semantic word and phrase model and a method of creating cultural dimensions and placing words along that dimension as suggested by Kozlowski et al. (2019). We created a Hebrew word and phrase model from Wikipedia using *gensim* (Rehurek & Sojka, 2011) and then focused on the cultural dimension of interest by creating an axis vector with the left end consisting of normalized vectors of the words "leftists," "left-wing," and "leftists" and right end being made up by the average vector of "rightist," "right-wing," and "rightists." Next, we normalized all rightist and leftist words and phrases used in our paradigm and projected them on our cultural axis, using cosine similarity. We found the projections of leftist and rightist words to be significantly different from each other ($p = .008$, $t = 3.009$, Cohen's $d = 1.346$), with rightist words being closer to the right end of the spectrum. There was no statistically significant difference between the good and bad word projections on the political axis ($p = .379$, $t = -.903$, Cohen's $d = -.404$), thus verifying the suitability of our paradigm.

The stimuli were the same for practice and test blocks, but the stimulus category labels (leftist/rightist, good/bad) were present on the bottom of the screen only during the practice blocks to avoid eye movements during the test blocks. Leftist/rightist words were in gray lowercase letters, while good and bad words were presented in yellow lowercase letters (Figure 1). IAT stimuli were presented until one of the two buttons on the response pad was pressed and interleaved with cross-hair fixation screens with a duration randomly varying between 852 and 1353 ms. Participants were notified when they made an error and asked to correct their

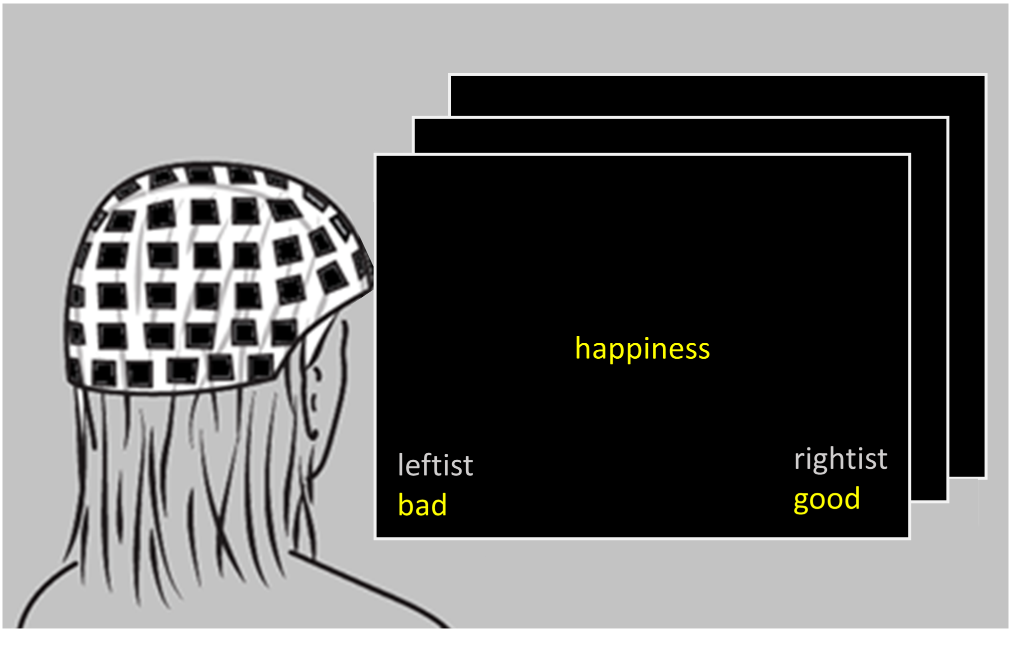

FIGURE 1 Experimental setup. The participants completed the IAT while MEG was monitoring their continuous neural activity. The IAT was in participants' native language: Hebrew.

response; these error trials were not included in the neural data analysis to avoid interfering processes like motor movement, surprise, and self-correction.

IAT study design

A general IAT design was applied (Greenwald & Lai, 2020) with modifications to optimize the design for MEG recording as detailed below. The mapping of the response buttons was stereotype congruent, assuming negative implicit association with outgroup members. Behavioral responses were generated by pressing with either the index or the middle finger of their right hand on a response pad, corresponding to each side of the screen and targeting one of the IAT categories. The IAT procedure was similar to a previous MEG-IAT study (Levy et al., 2021). The categories were combined as leftist-positive and rightist-negative in one test block and reversely in the other. In both test blocks participants sorted 80 stimuli. The order of blocks was counterbalanced across participants, that is, half of the participants first saw categories in the congruent mapping and half in the incongruent. Behavioral implicit bias marker was calculated using *D* scoring, with error response times included as the condition average plus 600 ms (Greenwald et al., 2003).

MEG set-up

We recorded ongoing brain activity (sampling rate 1017 Hz, online 1–400 Hz band-pass filter) using a whole-head 248-channel magnetometer array (4-D Neuroimaging, Magnes® 3600 WH) inside a magnetically shielded room. To be able to remove environmental noise, there were reference coils located approximately 30 cm above the head. The experimenter monitored participants' movements using five coils attached to the participants' scalp to record the head position relative to the sensor array.

Data preprocessing and MEG sensor and source-level analysis

The neural data was cleaned similarly to recent MEG studies (Zebarjadi et al., 2021, 2023). We excluded two MEG sensors from the analysis due to malfunction. We segmented the data into 2500 ms epochs with a baseline period of 500 ms corresponding to the IAT event trials, aligned with the stimulus onset as zero point. We analyzed only trials with a response time between 300 and 3000 ms, following IAT analysis recommendations (Greenwald et al., 2003). Epochs were filtered at 1–200 Hz range with 10s padding and resampled to 400 Hz.

We performed analyses on the neural data using MATLAB R2021B, R2011A (MathWorks®, Natick, MA, USA) and the FieldTrip software toolbox (Oostenveld et al., 2011). Time–frequency representations (TFRs) of power were calculated similarly to earlier studies (Zebarjadi et al., 2023) focusing on the induced responses.

We followed the analysis pipeline of earlier studies to conduct source-level analysis (Levy et al., 2021). We created a single shell brain model using an MNI adult template brain and adjusted it for each participant with SPM (Wellcome Department of Imaging Neuroscience, University College London, www.fil.ion.ucl.ac.uk) to fit their manually digitized (Polhemus FASTRAK® digitizer) head shape. Each participant's brain was fractioned into a grid, the spatial filters for each grid location were reconstructed by beamforming. These spatial filters were restricted to our time-frequency window of interest. Next, a virtual channel was made with the covariance window set as the window of interest, and the brain activity patterns were investigated in both political groups separately.

Statistical analysis

We employed IBM SPSS Statistics 28 (IBM SPSS Statistics for Windows, 2021) for statistical analyses. We tested the significance of the results using a paired two-tailed *t*-test and between rightist and leftists using an independent sample two-tailed *t*-test. To test the significance of *D* scores, we used a one-sample *t*-test. We tested for correlations using Pearson's correlation coefficient for the whole sample and political groups separately.

For neural data, we used a nonparametrical randomization procedure to obtain corrections for multiple comparisons (Maris & Oostenveld, 2007) for the time-frequency representations, topographical maps, and between-groups comparison. To start, the *t*-value of the contrast between incongruent and congruent conditions was calculated for each participant, sensor, frequency, and time, with the test statistic defined by pooling the *t*-values across all participants. We randomly multiplied each participant's *t*-value by 1 or −1 and summed across participants to permute the original conditions and evaluate the time-frequency clusters with a significant effect. This randomization procedure was repeated 1000 times. The significance thresholds were corrected by multiple comparisons method using the maximum and minimum clusters. This approach was used both on sensor and source level. The details of that statistical approach have been elaborated in publications following a similar process (Levy et al., 2018). To test for correlations between the sensor and source-level neural effects and other measures, we calculated incongruent-congruent power ratios, pooling across the peak frequencies, peak times, and peak sensors for each participant.

RESULTS

Rightists, compared to leftists, are less tolerant of the partisan outgroup at the self-report level

We calculated the average intolerance score for both groups separately and found that while leftists ($M \pm SD$, $1.252 \pm .397$) and rightists ($M \pm SD$, 2.091 ± 1.530) both have a low average intolerance score, it is still significantly higher ($p = .004$, $t(64) = 2.968$, Cohen's $d = .732$) for rightists, suggesting ideological asymmetry on the self-report level.

Both groups show implicit outgroup bias on the behavioral level, rightists more

To look at implicit bias on the behavioral level, we employed *D* scoring with positive *D* scores showing an implicit bias against the other partisan group and negative *D* scores reflecting an implicit bias against the participants' own group. The results of this investigation are in Table 1. First, we looked at the *D* scores for the full sample of participants and found the whole group to have an average positive *D* score ($M \pm SD$, $.381 \pm .388$), significantly differing from 0 ($p < .001$, $t(76) = 8.608$, Cohen's $d = .981$), implicating a clear implicit intergroup bias against the other political group for the full sample. To address the possibility of differences in noise in the data and to verify the suitability of *D* scores for our analysis as well as to see whether the results replicate if we would use response time differences between incongruent and congruent block, we calculated the correlation between the two measures and saw them to be closely

TABLE 1 *D* scores and statistics for all participants (including centrists), leftist and rightist groups separately, and the left–right statistical comparison.

	***D*-score (M ± *SD*)**	N_{total}	$N_{positive\ D\text{-score}}$	***t*-test statistics**
All	.381 ± .388	77	66	$p<.001$, $t(76)=8.608$, Cohen's $d=.981$
Rightists	.518 ± .312	35	34	$p<.001$, $t(34)=9.817$, Cohen's $d=1.659$
Leftists	.279 ± .417	31	23	$p<.001$, $t(30)=3.724$, Cohen's $d=.669$
Right versus left				$p=.010$, $t(64)=2.658$, Cohen's $d=.656$

related ($R=.917$**, $p<.001$), testifying for the suitability of *D* scores as a measure of IAT effect in our sample.

Next, we set out to see whether this measure of implicit bias surfaces differently in the leftist and rightist political groups, looking at *D* scores separately for leftists and rightists, excluding the centrist participants ($N=11$). The average *D* score was significant and positive for both rightists ($M \pm SD$, $.518 \pm .312$, $p<.001$, $t(34)=9.817$, Cohen's $d=1.659$) and leftists ($M \pm SD$, $.279 \pm .417$, $p<.001$, $t(30)=3.724$, Cohen's $d=.669$) separately. However, whereas 97.1% of rightists had an antileftist bias, only 74.2% of leftists displayed an antirightist bias, suggesting the bias to be more consistent for the rightists. This contributed to the fact that the *D* scores were significantly different between the two groups ($p<.001$, $t(64)=2.658$, Cohen's $d=.656$), confirming that even though both groups had an implicit behavioral bias against each other, this marker of bias against the other group was stronger in the rightist group. These results reproduced with response time differences ($p<.003$).

There was no significant correlation between the levels of political extremity and response time differences ($R=-.152$, $p=.224$, $N=66$) or the *D* scores ($R=-.144$, $p=.249$, $N=66$). However, to further support the ideological asymmetry on the behavioral level, the *D* scores were significantly correlated with self-reported political stance ($R=-.241$*, $p=.035$) and political intolerance ($R=.290$*, $p=.010$).

Additionally, we analyzed the *D* scores of centrist or close-to-centrist participants (political ideology scores 3–5 on a scale of 1–7) and found that their *D* scores did not significantly differ from zero ($N=29$, $p=.149$), confirming their mild attitudes about the polarization.

Only rightist group exhibit alpha rhythm suppression as a neural marker of intergroup bias at sensor level

We started our neural investigation of intergroup bias at sensor level with the full sample of participants and the 8–12 Hz and 100–500 ms post stimulus onset time-frequency-window, because alpha suppression in this time-window has been shown earlier to be related to intergroup bias (Levy et al., 2021). For leftists, 5.8% of trials in congruent and 6.7% in incongruent block were dropped due to errors, for rightists 6.5% in congruent and 10.5% in incongruent. Following the method described in the statistical analysis chapter and pooling across all channels and participants of the group in this time-frequency range separately for rightists and leftists, we found that as the alpha suppression was strong and significant in the rightist group ($p_{cluster\text{-}cor}=.018$), it was missing in the leftist group ($p_{cluster\text{-}cor}=$ N/A), suggesting that intergroup bias differs between the political groups on the neural level. Surprisingly, the leftists showed a nonsignificant alpha enhancement instead ($p_{cluster\text{-}cor}=.128$), loosely suggesting a reversed pattern: an antileftist bias also for the leftist group.

Investigating the effect further by pooling over times and frequencies in this range, we found a significant suppression ($p_{cluster\text{-}cor}=.023$) for the rightist group on the right-side sensors, and no suppression ($p_{\text{cluster-cor}} = .555$) for leftists. Again, instead there was a small (nonsignificant) alpha enhancement ($p_{\text{cluster-cor}} = .244$) in the leftist subgroup. Thus, we have found similar modulations in alpha rhythmic activity as previous implicit bias research, but only in the rightist group. Next, we further explored the difference between the political groups.

We compared the incongruent-congruent contrasts of rightists and leftists in the time-frequency window of interest pooled across all channels (Figure 2A) and found a significant ($p_{\text{cluster-cor}} = .020$) difference in early alpha power, suggesting a significant difference in out-group bias between the rightist and leftist. We then chose the peak times and frequencies from this result ($t(64) < -2.8$, 150–250 ms, 9 Hz) and averaged over these to locate the peak sensors (Figure 2B). We found a significant negative cluster ($p_{\text{cluster-cor}} = .019$). We then calculated the power ratio, pooling across the five peak sensors (A174, A146, A182, A193, A173) of this suppression, the described peak frequencies, and peak times, to get a single sensor-level suppression value for each participant (hereafter, sensor peak). We compared these sensor peaks between leftists and rightists and found that while the rightists have a significant average suppression, the leftists act differently. This suggests that the bias is significantly different between the two groups at the neural level, and that in the leftists there seems to be no significant neural bias against the rightists.

Next, we conducted a series of correlation analyses with implicit and explicit measures to test the validity of our sensor-level peak as a marker of intergroup bias. The sensor peak from Figure 2 was not significantly correlated with the *D* scores ($R = .014$, $p = .906$) nor with political intolerance ($R = -.179$, $p = .119$), suggesting there could be several bias mechanisms at play. We will further explore this idea at the source level.

However, we found a significant correlation with political orientation ($R = .458^{**}$, $p < .001$, Figure 2C). These findings confirm that our neural marker could have the potential to reflect a process behind the ideological asymmetry in intergroup bias and give reason to continue the investigation on the source level.

Source-level investigation reveals both leftists and rightists controlling for automatic bias against the leftists

As the sensor-level investigation revealed interesting patterns in our chosen time-frequency window of interest, we chose the same window (100–500 ms) for source-level analysis. Using beamforming for the full sample of participants with a wide alpha range (6–14 Hz) and the

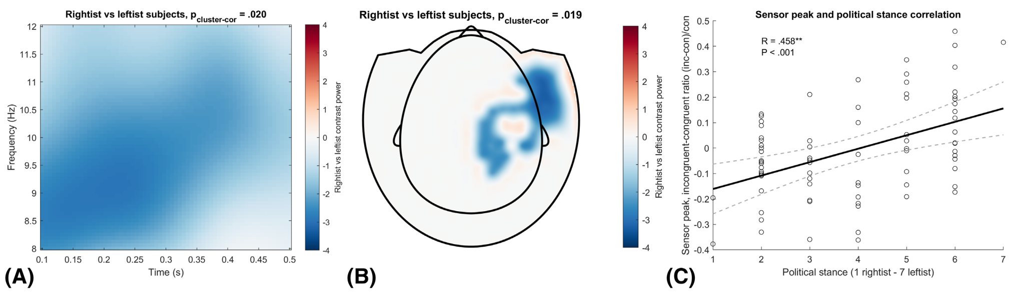

FIGURE 2 (A) Time-frequency representation for rightists versus leftists incongruent-congruent power contrast in 8–12 Hz, 100–500 ms range. The area selected for further investigation was 150–250 ms and 9 Hz. (B) Topographical plot for 150–250 ms, 9 Hz, peak area from a. The peak sensors of the significant suppression shown here are A174, A146, A182, A193, A173. (C) Significant correlation of the sensor peak across all participants (pooled across peak frequency 9 Hz, peak times 150–250 ms, peak sensors A174, A146, A182, A193, A173) with political stance (with 1 reflecting extreme right and 7 extreme left).

peak at 10 Hz, we found a significant ($p_{\text{cluster-cor}} = .004$) suppression peaking in the dorsal anterior cingulate cortex (dACC) and medial prefrontal cortex (mPFC), areas associated with controlling for automatic bias, as shown in Figure 3A. We created a virtual channel from this peak and repeated our analysis process from sensor level with this new channel. Leftists versus rightists group comparison revealed a significant difference ($p = .008$) with a peak ($t(66) < -2.5$) at 9–10 Hz and 250–300 ms. Averaged over these peak values, we saw a significant suppression for the rightists ($p = .040$) and a significant enhancement for leftists ($p = .014$), as shown on Figure 3B. So it seems activity in this region surfaces for both political groups when making leftist-positive and rightist-negative associations.

This window was chosen as our source-level peak and used for correlation analyses. We found that it correlates significantly with our sensor-level peak ($R = .225$*, $p = .049$, Figure 3C), suggesting the source's relevance for our investigation. Further, similarly to the sensor-level peak, it had no significant correlation to D scores ($R = .028$, $p = .808$) or political intolerance ($R = -.173$, $P = .132$) but was significantly correlated to political stance ($R = .294$**, $p = .009$, Figure 3D). Taken together, these correlations suggest that while our source-level peak reflects controlling for automatic bias and is related to ideological

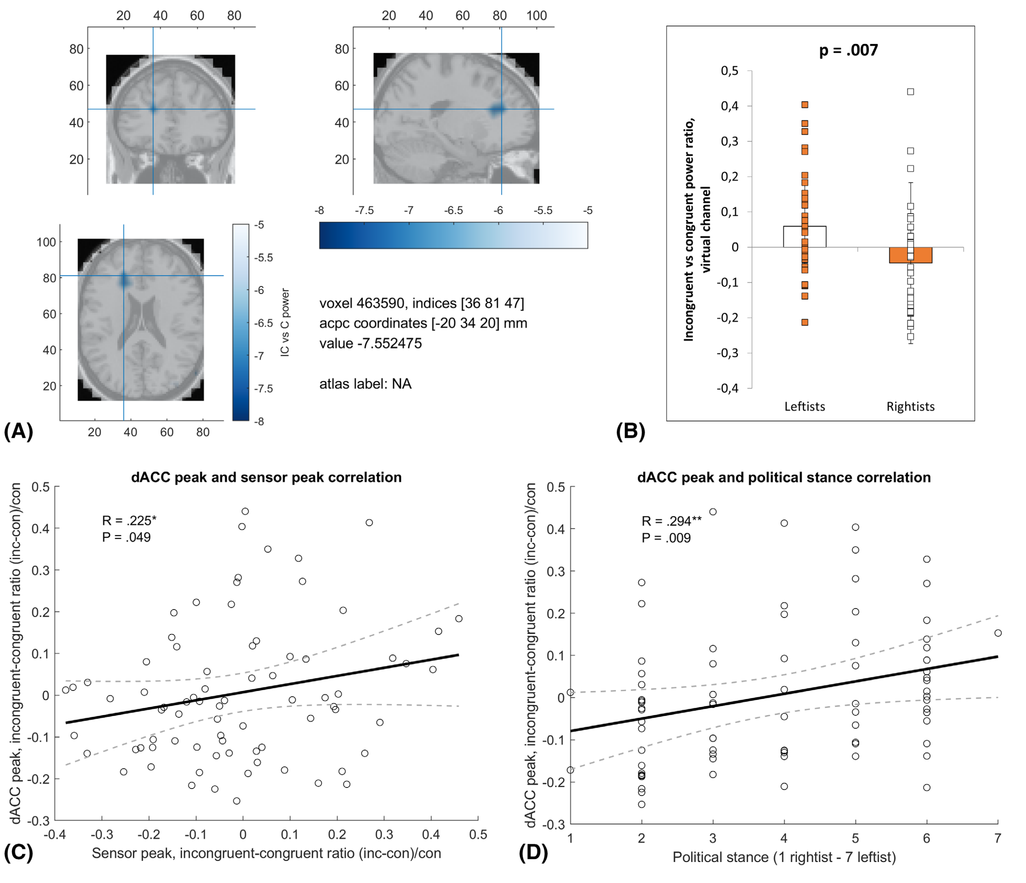

FIGURE 3 (A) Source peak location for a beamformer created for 100–500 ms with the peak at 10 Hz. The suppression peaks at MNI coordinates [−20.0 34.0 20.0], with the suppression estimated to originate from dACC & mPFC. (B) Histogram with ratios (inc-con)/con calculated from neural power values averaged over the virtual channel created at the peak showed in 2A, 9–10 Hz and 250–300 ms, (C, D) Significant correlations of the source peak across all participants (pooled across peak frequencies 9–10 Hz, peak times 250–300 ms, virtual channel created at source peak) with c. sensor-level peak, (D) political stance (with 1 reflecting *extreme right* and 7 *extreme left*).

asymmetry, there is still some bias-related brain activity uncharted. For this reason, we decided to look into motor-control-related suppression around the time of the response-button presses.

Neural component related to decision-making and motor control reflects traditional marker of implicit bias

Looking into the full (1–40 Hz, −.5–2 s) TFR of the IC-C contrast of the full sample, we focused on the peak of the suppression ($t(77) < -3$, 800–1400 ms and 14–27 Hz). To validate our choice, we created a topographical plot averaged over these times and frequencies. The resulting plot had a significant suppression ($p_{\text{cluster-cor}} < .001$) in the motor cortex area (Figure 4A), which suggests the suitability of the chosen window. Next, we created a beamformer using the same peak window (14–27 Hz, 800–1400 ms, smoothing 6 Hz, peak 20 Hz) and found a significant ($p = .002$) suppression peaking at pre- and postcentral gyrus (Figure 4B), thus reflecting decision-making and movement processes. We created a virtual channel from the peak shown in Figure 4B and found the peak of this activity ($t(77) < -3$) at 21–22 Hz 1150–1250 ms poststimulus onset. Averaging over these peak times and frequencies, we compared the power value ratios for leftists and rightist participants (Figure 4C) and for leftist participants with

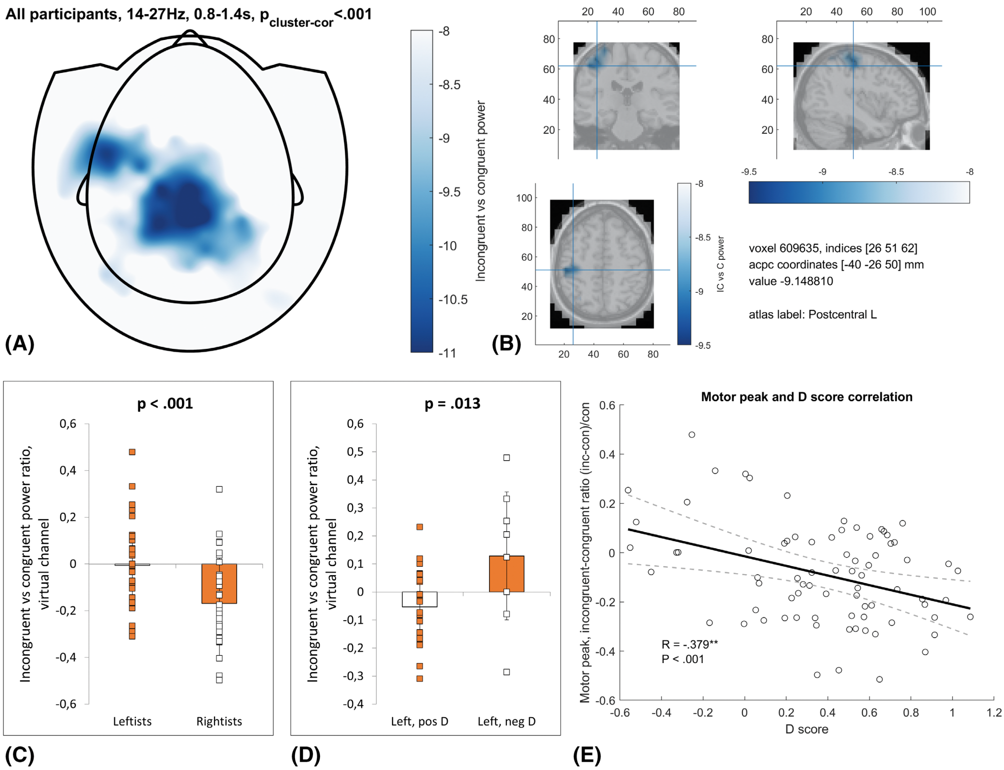

FIGURE 4 (A) Topographical map of sensor-level suppression, full sample of participants, 800–1400 ms, 14–27 Hz, incongruent versus congruent condition power contrast. (B) Location of the peak of source-level suppression, MNI coordinates [−50.0 −34.0 50.0], translating to pre- and postcentral gyrus. (C) (Inc-con)/con ratios calculated using neural power values averaged over the peak suppression of incongruent versus congruent contrast for the full sample of participants: 21–22 Hz, 1150–1250 ms, leftist versus rightist participants. (D) Same values as in 4C, compared between leftists with positive and negative *D* scores. (E) Motor peak (21–22 Hz, 1150–1250 ms, location shown in 4B) correlation with *D* scores.

positive and negative D scores (Figure 4D). We found out that even though both leftists and rightists showed an average suppression, it was still significantly ($p < .001$) stronger for rightists, providing sufficient evidence to reject the first null-hypothesis. This asymmetry was well explained by the D scores, as leftists with positive D scores showed an average suppression and leftists with negative D scores showed an average activation, resulting in a significant ($p = .013$) difference between the groups. Furthermore, we found the motor peak to be correlated with D scores ($R = -.379$**, $p < .001$, Figure 4E), which suggest D scores to be strongly tied to decision-making and motor-control processes. The motor suppression was also correlated with political stance ($R = .309$**, $p = .006$), but not with political intolerance ($R = -.096$, $p = .407$).

This source peak was not correlated with the source peak found from dACC & mPFC ($R = -.067$, $p = .564$) nor the sensor-level peak ($R = .116$, $p = .314$). In summary, we found two neural measures that contribute to ideological asymmetry in outgroup bias. While behavioral implicit asymmetry was better explained by the neural component related to decision-making and motor control, there was another outstanding neural component associated with perception functioning accounting for major asymmetry on the neural level.

DISCUSSION

We investigated whether the self-report, behavioral and neural determinants of outgroup bias reveal ideological asymmetries, using a novel combination of IAT and MEG. We found a significant difference between the two political camps reflecting bias control. Further analysis revealed another neural rhythmical component contributing to intergroup bias reflecting response control. As we add to neuropolitical research and the debate about ideological asymmetry in outgroup bias, we further confirm the validity of alpha oscillation suppression as a marker of intergroup bias.

First, we found a clear difference in outgroup bias in self-report levels using the political intolerance scale, with rightists being more intolerant of the other camp, adding to the debate (Crawford & Pilanski, 2014; Lindner & Nosek, 2009). Next, we found a clear D score differing from zero, also known as the behavioral IAT effect, for the whole group of participants. D scores work best if viewed as a relative, not an absolute measure, so we will not make any conclusions based on the overall size of the scores (Jost, 2019). The effect was significantly stronger on the rightist side, countering the earlier findings of political right and left being fairly similar in their implicit biases (Arcuri et al., 2008; Knutson et al., 2006). Some of the leftists displayed a counterstereotypical D score effect, suggesting a possible bias against their own political group and the possibility of IAT revealing the implicit knowledge of cultural norms (Axt et al., 2018).

Comparing the neural oscillations of incongruent and congruent IAT conditions, we found alpha rhythm suppression, which is expected in task-relevant areas (Jensen & Mazaheri, 2010; Williamson et al., 1997) and can be viewed similarly to neural activation in fMRI, to originate from dACC and mPFC. Social neuroscience research has suggested a model of bias control where both dACC and mPFC are involved in the monitoring process which signals the regulatory system if needed. More specifically, dACC detects the activation of internal cues for bias and initiates the need to control for automatic bias, and mPFC is responsible for normative, external cues for control. According to this theory, these areas activate when a conflict is detected between activated bias (i.e., automatic response) and an intended alternative response (Amodio et al., 2004; Amodio & Cikara, 2021; Richeson et al., 2003). Interestingly, low-bias participants have previously exhibited better control on inhibiting automatic responses, resulting in greater conflict-monitoring activity (Amodio et al., 2008). Coming to politics, earlier studies have shown liberals to exhibit significantly greater ACC activity in response conflict situations than conservatives, indicating control in dealing with new information (Amodio et al., 2007; Jost & Amodio, 2012). Given the political context in Israel, we can interpret the alpha suppression in the incongruent-congruent contrast of the rightist group as having to deal with a slower, less effective process of monitoring conflict for bias control.

Put in other words, the missing effect in leftists likely reflects the activation of automatic stereotypes against both rightists and leftists (Axt et al., 2018), confirming the minority position of leftists in Israel which often results in antileft derogatory public discourse (Maor et al., 2020; Piurko et al., 2011; Tamar et al., 2022). Research has shown 40%–50% of disadvantaged group members have a tendency to implicitly favor outgroups (Jost, 2019; Jost et al., 2004), often showed in the context of African Americans' implicit bias against their own race, possibly driven by system justification (Ashburn-Nardo et al., 2003; Axt et al., 2018) and cultural learning (Axt et al., 2018). In the political context, a recent review named ego and system justification to increase outgroup bias in rightists (Jost et al., 2022), but it does not explain the outgroup favoritism in leftists since people commonly vote for the people they favor. The cultural learning theory, however, explains the leftist behavior. Most Israelis support right-wing political ideology (Piurko et al., 2011): In 2022, 62% of Jewish Israelis self-defined as rightists, whereas only 11% as leftist (Tamar et al., 2022), resulting in the crystallization of antileft derogatory speech in public discourse and signaling a favorable right-wing majority position.

The neural effect we found by comparing the political groups on both sensor and source level was in direct correlation with political inclination and on source level also with political intolerance, showing a relation to explicit measures. However, while *D* scores reflected implicit bias against the outgroup in both political camps, the neural peaks only captured a biased response in the rightists group. For this reason, we additionally looked at later beta suppression. We identified a low beta (15–21 Hz) suppression peaking 1050–1250 ms poststimulus and originating from pre- and postcentral gyrus, reflecting decision-making and motor-control-related neural processes (Banker & Tadi, 2022). It was significantly correlated with *D* scores, and further, leftists with a negative *D* score exhibited a beta enhancement, whilst rightists and leftists with a positive *D* score showed beta suppression. We argue the late beta component reflects traditional implicit bias, similarly reported in another study (Schiller et al., 2016).

Studies consistently find leftists and rightists to be similarly prejudiced and politically intolerant of political outgroups (Crawford & Brandt, 2020; Johnston & Madson, 2022). However, even though we used the political groups themselves as targets, we observed a clear asymmetry in how the brains of leftists and rightists in Israel relate to the other camp and themselves, with rightists exhibiting more outgroup bias on all three levels of investigation—explicit self-reports, IAT *D* scores, and neural oscillations: early alpha reflecting automatic bias control and late beta reflecting response control, countering earlier findings of similar feelings towards the other political camp in Israel (Hasson et al., 2018). Adding to the asymmetry, both groups showed an anti-leftist bias. As argued before, taking a unidimensional approach to political ideology can lead to oversimplified results, and different aspects of the ideology reflect different forms of bias (Crawford & Brandt, 2020). The right–left orientation scale might have different meanings in different countries (Aspelund et al., 2013). In Israel, the political orientation has been shown to reflect conservation values; Israelis view themselves as more rightist compared to many European countries (Piurko et al., 2011), and, importantly, the two sides of the polarization in Israel do not match the classic description of right and left wing. Even though one side can be clearly defined as the conservative right wing, their opposing front consists of center right, center, left, and The Joint Arab List (Maor et al., 2020). Thus, even though the votes distribute quite evenly between the two blocks, Israel leans right (62% self-define as rightists), and so the rightist worldview holds more power (Tamar et al., 2022). Continuing that argument, the liberal leftists screened in our study are clearly a minority in Israel, especially in comparison to the conservative rightists. We thereby suggest the symmetry of political polarization to be context dependent.

Previously, political neuroanatomical and functional differences have been reported (e.g., Haas et al., 2020; Nam et al., 2018), but to our knowledge the rhythmical response to bias has not been researched in relation with political inclination yet. Unraveling effects overlooked by the behavioral implicit intergroup bias measure, our study has implications for the neuroscience of ideological asymmetry and offers a new marker of implicit intergroup bias. Furthermore, our study contributes to the understanding of intergroup bias in general, building on previous research suggesting the alpha rhythm to unite multiple components of bias and showing how these components contribute to the overall strength of bias. Most importantly, our results shed light on the political climate and power relationships in Israel—specifically the weak position of leftists.

MEG studies are typically much smaller (i.e., *N* typically ranging from 10 to 25) (Baldauf & Desimone, 2014; Levy, Vidal, et al., 2016) compared to behavioral studies due to technical and logistical constraints. Thus, the sample size in this MEG study is relatively large, and we find strong and consistent effects across all three levels (explicit, implicit, neural), thereby increasing the reliability of the findings reported here; of course, these important findings need to be reproduced in various political contexts, and until then, generalization of the findings beyond the current context warrants caution. In addition, follow-up studies would benefit from analyzing the often-neglected centrists compared to noncentrists in polarized contexts for a more comprehensive overview of the political climate.

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DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors upon reasonable request, pending institutional ethical policies. The study was not preregistered.

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