New Vistas for the Relationship between Empathy and Political Ideology

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Abstract

The study of ideological asymmetries in empathy has consistently yielded inconclusive findings. Yet, until recently these inconsistencies relied exclusively on self-reports, which are known to be prone to biases and inaccuracies when evaluating empathy levels. Very recently, we reported ideological asymmetries in cognitive-affective empathy while relying on neuroimaging for the first time to address this question. In the present investigation which sampled a large cohort of human individuals from two distant countries and neuroimaging sites, we re-examine this question, but this time from the perspective of empathy to physical pain. The results are unambiguous at the neural and behavioral levels and showcase no asymmetry. This finding raises a novel premise: the question of whether empathy is ideologically asymmetrical depends on the targeted component of empathy (e.g., physical pain vs cognitive-affective) and requires explicit but also unobtrusive techniques for the measure of empathy. Moreover, the findings shed new light on another line of research investigating ideological (a)symmetries in physiological responses to vicarious pain, disgust, and threat.

Key words: empathy; neuroimaging; pain empathy; political ideology

Significance Statement

In this study, we challenge the historically inconclusive findings on ideological asymmetries in empathy. By employing neuroimaging techniques, we demonstrated that ideological asymmetry in physical pain empathy is absent. This research underscores the importance of considering various facets of empathy, societal contexts, and unbiased measurement methodologies, such as neuroimaging techniques, in the assessment of empathic responses.

Introduction

The growing body of literature on the interplay between political ideologies and psycho-physiological processes reveals mixed findings (Wagaman and Segal, 2014; Waytz et al., 2016; Hasson et al., 2018; Morris, 2020; Smith and Warren, 2020). A number of these studies have proposed the existence of potential biopsychological underpinnings to political ideologies. For instance, to examine possible ideological differences in levels of empathy, several researchers reported enhanced empathy among "leftists" (i.e., ideological left, or liberals) compared with "rightists" (i.e., ideological right, or conservatives; Wagaman and Segal, 2014; Hasson et al., 2018; Morris, 2020). However, other studies failed to reproduce those findings (Waytz et al., 2016) or even reported reversed patterns (Casey et al., 2023). A potential factor contributing to this inconsistency might be the monolithic definition of the term "empathy," often overlooking context and nuanced distinctions. Recently, it has been proposed that empathy researchers should relate to empathy as a multifaceted

social-cognitive phenomenon, encompassing diverse components, such as physical pain, affect, mentalization, and empathic care (Lamm et al., 2007; Weisz and Cikara, 2021). The involvement of each component may vary depending on how empathy is triggered during the experimental procedures (Lamm et al., 2011; Bruneau et al., 2012), highlighting the importance of considering the type of stimuli, context, and individual factors.

An alternative explanation for the heterogeneous findings is the methodology for assessing empathy. To date, the interplay between empathy and political ideology has been predominantly examined using self-reports (Pliskin et al., 2014; Wagaman and Segal, 2014; Hasson et al., 2018; Morris, 2020). Yet, various empathy scholars have unraveled the benefits and promises of the neuroscientific perspective on the multiple facets of empathy (Zaki and Ochsner, 2012; Schreiber, 2017; Weisz and Cikara, 2021; Zebarjadi et al., 2023). Very recently, the first neuroimaging study explored the relationship between political ideology and affective-cognitive empathy (Zebarjadi et al., 2023). In that study, a brief story of characters was depicted, followed by displaying several distressing emotional or neutral pictures of them. This sort of stimulation requires participants to mentalize with the characters of the stories throughout the assessment. Brain activation during this task was localized in the temporal parietal junction (TPJ), an area associated with perspective-taking and the cognitive facet of empathy. This study revealed that compared with left-wing, right-wing ideological values are associated with reduced neural underpinnings of affective-cognitive empathy.

Although that study was valuable for consolidating the relationship between political ideology and empathy, it remains underexplored whether this relationship might depend on the subprocesses of empathy (Weisz and Cikara, 2021). In particular, although previous studies reported ideological asymmetry in relation to cognitive and affective facets of empathy (Wagaman and Segal, 2014; Hasson et al., 2018; Morris, 2020; Casey et al., 2023; Zebarjadi et al., 2023), it was rarely examined whether empathy to vicarious physical pain is also ideologically sensitive. The debate on ideological asymmetry largely centered on the neural and physiological responses to images depicting vicarious physical pain, threat, and disgust (Oxley et al., 2008; Ahn et al., 2014; Bakker et al., 2020; Brandt and Bakker, 2022), with Oxley et al. (2008) being one of the pioneering studies. They suggested that individuals with higher physiological reactivity to threatening stimuli were more likely to endorse conservative policies, whereas those with lower sensitivity leaned toward liberal stances. However, subsequent studies found conflicting evidence, with Bakker et al. (2020) failing to replicate these results and Brandt et al. (2014b) arguing that both conservatives and liberals may react similarly to threatening stimuli (Brandt et al., 2014b; Bakker et al., 2020; Brandt & Bakker, 2022). This ongoing debate emphasizes the need for further exploration and more accurate methods to understand the interplay between psychophysiological traits and political inclinations (Smith and Warren, 2020).

Building on those recent findings, we extend our investigation to examine whether empathy toward vicarious physical distress and pain is ideologically independent (Zebarjadi et al., 2023). To increase the reliability of the study, we employ two important strategies that have been neglected in the past literature: First, neuroimaging (MEG) is implemented in conjunction with various behavioral and self-reported measures of empathy. Many past MEG studies proved that empathy toward vicarious physical pain and suffering triggers a clear and robust neural response (Perry et al., 2010; Whitmarsh et al., 2011; Motoyama et al., 2017; Levy et al., 2018; Zebarjadi et al., 2021; Zebarjadi and Levy, 2023). These studies indicated that the neural mechanism underlying empathy mainly reported the involvement of the alpha rhythm. Besides, other studies pointed out a positive correlation between the suppression of alpha-band power and functional activation in a specific brain region (Jensen and Mazaheri, 2010; Schubring and Schupp, 2021). Therefore, based on the robust findings in the previous MEG studies on empathy, in the current study, we examined the neural response within the alpha-band range. Second, a large neuroimaging sample was used in two different continents and experimental sites to increase the generalizability of findings.

Materials and Methods

Study 1

Participants

Seventy-seven healthy Jewish Israeli participants (36 females; mean age ± SD, 25.3 ± 3.83, 46 politically rightist and 31 politically leftist) participated in this study. Before the recruitment, subjects were assessed for MEG compatibility as well as their psychiatric and neurological history. In addition, participants were asked to report their demographics (such as gender, and age) and political ideology. All instructions were delivered in the participants' native language, and they were remunerated for their participation in the study. The ethics committee at IDC Herzliya approved the study, and all participants signed the consent form.

Stimuli

A set of well-validated stimuli, similar to our previous experiments (Levy et al., 2016, 2018; Pratt et al., 2016; Zebarjadi et al., 2021), was used in this study. The stimuli consisted of 108 digital color pictures of limbs (half) in physical pain such as injuries or wounds to depict painful (P) conditions (to elicit pain empathy) and (half) in nonpainful (N) conditions (to control for other factors). Stimuli were displayed randomly in a standardized size at the center of the monitor with a visual angle of 20.96° × 15.37° for 1 s, with an interstimulus interval of 2.5 to 3.3 s. In addition, we randomly presented twirl filler trials using a short twisted movement in new stimuli to maintain participants' attention, and participants were trained to press a response button when they detected these twirl stimuli. The filler trials were not included in the data analysis.

Procedure

The experiment was programmed by E-Prime software (Psychology Software Tools). Participants were placed in a supine position inside the MEG system, facing the screen projecting the stimuli, and were instructed to maintain a relaxed posture, avoid moving their limbs, and focus their attention on the presented stimuli. The participants underwent MEG screening using a whole-head 248-channel magnetometer array (4-D Neuroimaging, Magnes 3600 WH) inside a magnetically shielded room while observing the stimuli on the screen. To track the participants' head positions relative to the sensor, five coils were attached to their scalps. To minimize environmental noise, reference coils were placed ~30 cm above the participants' heads and aligned with the *x*-, *y*-, and *z*-axes. The sampling rate was set at 1,017 Hz, and a bandpass filter limited the frequency range to 1–400 Hz. After the scanning session, participants filled out several questionnaires to evaluate their empathic level and ideology.

Brain data analysis

Sensor analysis. The analysis for this study was done by MATLAB (MathWorks) and the FieldTrip software (Oostenveld et al., 2011). The data were bandpass filtered with the frequency range of 1–40 Hz, and eye and heart artifacts were eliminated from the raw data, using independent component analysis (ICA). The runICA algorithm was used with the rejection threshold of 4×10^{-12}. Components corresponding to artifacts were identified through visual inspection of their time courses and topographies, focusing on patterns characteristic of eyeblinks and heartbeats. In addition, we visually inspected the data and discarded any remaining bad trials. Data were analyzed in alignment with the onset of the stimuli detected by the trigger. Based on previous MEG studies on empathy (Whitmarsh et al., 2011; Levy et al., 2018; Zebarjadi et al., 2021), epochs of 2 s after each stimulus onset were selected for further examination. To calculate the fast Fourier transform (FFT) on short sliding time windows of 500 ms, Hanning tapers were applied to each sensor data, and time–frequency representations (TFRs) of power for the alpha range (6–14 Hz) and each trial were calculated. Subsequently, the power estimates were averaged across all the trials and the statistical contrast between the two conditions (pain vs neutral) was calculated and adjusted for multiple comparisons, using a nonparametric permutation approach (more detail was provided below, Statistical analysis). Finally, by averaging over the significant time–frequency (TF) window on the peak sensor, a single averaged power value for each subject was obtained and the contrast between the averaged power values of subjects in the two opposing political groups was calculated.

Source analysis. To localize the source, we digitized the head shape of the participant during the MEG measurement (Polhemus FASTRAK digitizer) and used it to modify an MNI template using SPM8 (Wellcome Centre for Imaging Neuroscience, University College London, www.fil.ion.ucl.ac.uk) to build a single shell brain model for each subject. We divided the brain volume of the subject into 1 cm grids using a linear transformation. This individualized grid and the statistically significant TF window, detected through sensor-level analyses, were used as basic information for implementing beamforming techniques. For each grid position, spatial filters were created to selectively pass activity in the defined time window and from the specific location of interest while suppressing irrelevant activity. In the next step, we extracted the peak activity coordinates and conducted a virtual channel (VC) analysis on them to examine the alpha power changes for each experimental condition over time. Similar to the sensor-level analysis, we calculated a single averaged power value for each subject by averaging over the significant TF window on the peak source. Eventually, the contrast between the averaged power values of subjects in the two opposing political groups was calculated.

Statistical analysis. As typically implemented in MEG studies of empathy (Whitmarsh et al., 2011; Levy et al., 2016, 2018; Zebarjadi et al., 2021, 2023), we extracted a neural representation of empathy and then applied an independent *t* test to compare the representations in the two tested groups (i.e., rightists vs leftists). Power representations of empathy processing were computed for each subject, channel, frequency, and time. These *t* values were pooled over all group participants to define the test statistic. The TF clusters with significant effects at the random effects level were searched. The results were corrected for multiple comparisons along the time, frequency, and channel dimensions. To evaluate the multiple-comparisons corrected significance thresholds for a two-sided test, the smaller of the two fractions was then retrained and divided by 1,000. The proportion of values in the randomization distribution that exceeded the test statistic represents the Monte Carlo significance probability, known as the *p* value (Maris and Oostenveld 2007). This cluster-based nonparametric approach allowed to correct for multiple comparisons in all brain analyses. For nonsignificant results, Bayesian factors were computed in order to evaluate whether these results are supportive of the null hypotheses.

Study 2
Participant

Forty-eight healthy native Finnish participants (37 females; mean age ± SD, 19.3 ± 1.71, 22 politically rightist and 26 politically leftist) were recruited on the Aalto University campus for this study. Subjects underwent screening for MEG compatibility and their medical background regarding psychiatric and neurological conditions before recruitment. In addition, participants were asked to report their demographics (such as gender and age) and political ideology. One subject was excluded after data acquisition measurement due to huge noises caused by the dental wire.

Instructions were provided in the participants' native language (Finnish), and they received compensation for taking part in the study. The study was approved by the ethics committee at Aalto University, and the consent form was signed by all participants.

Stimuli

The stimuli employed in this study were identical to those used in Study 1. Every three stimuli of the same type were randomly grouped into a block, and blocks were randomly presented to the participants. Each stimulus was displayed in a standardized size at the center of the monitor with a visual angle of 20.96° × 15.37° for 1 s with 3–3.5 s interstimulus intervals and ~15 s interblock intervals. Similar to Study 1, the same techniques to maintain participants' attention were employed.

Procedure

The experiment was programmed by Presentation software (Presentation; Neurobehavioral Systems). The participant sat in a relaxed position inside the MEG scanner, in front of a screen presenting the stimuli, and was asked to avoid movement during the measurement. Participants' brain activity was captured using a whole head 306-channel MEG (Elekta Neuromag), located at the MEG Core section of Aalto neuroimaging infrastructure at Aalto University. The MEG device was in a magnetically shielded room that was equipped with an active noise cancellation system and a three-layer covering to minimize external magnetic fields. To ensure accurate measurements, five head position indicator (HPI) coils were attached to the participants' scalps. The positions of the coils were recorded for each individual, and continuous HPI was applied throughout the recording. Additionally, electrooculography (EOG) electrodes were used to record eyeblinks and saccades during the measurement. The sampling rate was 1,000 Hz and a bandpass filter (0.1–330 Hz) was applied. After the MEG measurement, participants filled out several questionnaires to evaluate their empathic level and ideology.

Brain data analysis

In this study, the preprocessing was done using the MNE-Python toolbox (Gramfort et al., 2013). MaxFilter software (Elekta Neuromag) was used to filter the raw MEG data, reducing measurement artifacts and magnetic interference, and compensating for head movements. Then the data were bandpass filtered at 1–40 Hz, and eye and heart artifacts were detected and removed by the ICA method. The fastICA algorithm was used with the rejection threshold of 4×10^{-12} and $4,000 \times 10^{-13}$ for mag and grad, respectively. Artifact-related components were identified by visually inspecting their time courses and topographies, particularly to typical patterns of eyeblinks and heartbeats. In the next step, similar to previous empathy studies looking into induced oscillatory responses, the epoch of 2 s after the stimuli onset was selected. Sensor, source, and statistical analysis for Study 2 were done almost in the same way as done in Study 1, using MATLAB (MathWorks) and the FieldTrip software to compare the findings of the two studies. The only difference was that the single shell brain model that was built based on the individual MRI and not the digitized head shape during MEG.

Self-reported measures

Political ideology scale. Participants rated their general political ideology using a 7-point political ideology scale ranging from 1 (extreme rightist) to 7 (extreme leftist). Participants who rated 1–3 on the self-reported political ideology scale explicitly reported that they are rightists (extreme, medium, light), and we classified them as the rightist group, and those who rated 5–7 explicitly reported that they are leftists (light, medium, extreme), and we classified them as the leftist group. For the Israeli dataset, we assessed the subjects' reading habits by asking them to rate their preferences for two national newspapers in Israel: the left-leaning Ha'aretz and the right-leaning Israel Hayom on a scale from 1 (not at all) to 7 (all the time). These reading habit ratings were used first to verify the results of the political ideology scale and second to assign those who scored 4 to either the leftist or rightist group. No inconsistency was found between the results of the political ideology and reading habit scales. For the Finnish dataset, the validation of the political ideology scale and categorization of those who scored 4 were done based on other scales such as the initial online survey and the right-wing authoritarian (RWA) scale.

RWA scale. Participants provided ratings on items related to authoritarianism on a scale ranging from 1 (strongly object) to 7 (strongly agree). These items were derived from questionnaires on right-wing authoritarian (RWA; Altemeyer, 1983). The purpose of this scale was to assess the extent to which participants showed respect for and supported traditional values promoted by authorities. Previous research has indicated that individuals who scored higher on this scale typically exhibited a greater inclination toward right-wing political ideology (Manganelli Rattazzi et al., 2007).

Vicarious Pain Questionnaire. Participants were asked to watch 16 painful videos and answer questions related to perceived pain while watching each video. This scale measures pain perception (Grice-Jackson et al., 2017) and evaluates vicarious pain (i.e., pain empathy) from a more ecologically valid perspective. The two main questions used in the current study measure pain intensity and discomfort experienced by watching each stimulus, respectively. In total, 14 out of 124 participants did not complete the Vicarious Pain Questionnaire (VPQ) ratings.

Interpersonal Reactivity Index. Participants rated "empathic concern" (EC) and "perspective taking" (PT) subscales of the Interpersonal Reactivity Index (IRI) questionnaire (Davis, 1983) to assess their trait empathy.

Results

Whole sample

The sensor analysis of all 124 subjects, contrasting painful and nonpainful conditions, determined a significant alpha power suppression pattern between the two conditions (negative $p_{cluster-cor} < 0.001$; $T = -7.74$; permutation test) with greater desynchronization in the pain condition, in the time window of 500–900 ms. The number of frequencies, time points, and channels for this permutation test were 9, 41, and 1, respectively. Figure 1, *A* and *B*, represents the TF representation on all subjects and the topographic MEG sensor representation of the same pain empathy contrast of each dataset, respectively. To evaluate the difference between the two political groups (68 rightist and 56 leftist subjects), a raincloud histogram is illustrated in Figure 1C, representing the power contrast values between the two conditions in the significant TF window ($F = 6$–14 Hz; $T = 500$–900 ms) for subjects in each political group. In contrast to earlier findings in (Zebarjadi et al., 2023), the difference between the leftists' and rightists' empathy levels is not significant ($p = 0.92$, independent *T* test). Bayesian factor showed moderate support for the null hypothesis (BF = 0.19), namely, that there is no difference between rightists and leftists. In addition, nonsignificant correlations between sensor neural results, and two different political-related scales (political ideology rating and RWA rating), are represented in Figure 1D.

Due to the use of different MEG machines with varying numbers of sensors for each dataset of the current study, a source analysis was conducted separately for each study. This enabled us to evaluate the empathy difference to vicarious physical pain both at the sensor and source levels between the rightist and leftist groups.

Study 1

Whole-brain sensor analysis (contrasting the two conditions) on 77 participants within the alpha range, shown in Figure 2A, revealed a significant suppression in alpha power (negative $p_{cluster-cor} < 0.001$; $T = -5.4$; permutation test). The number of
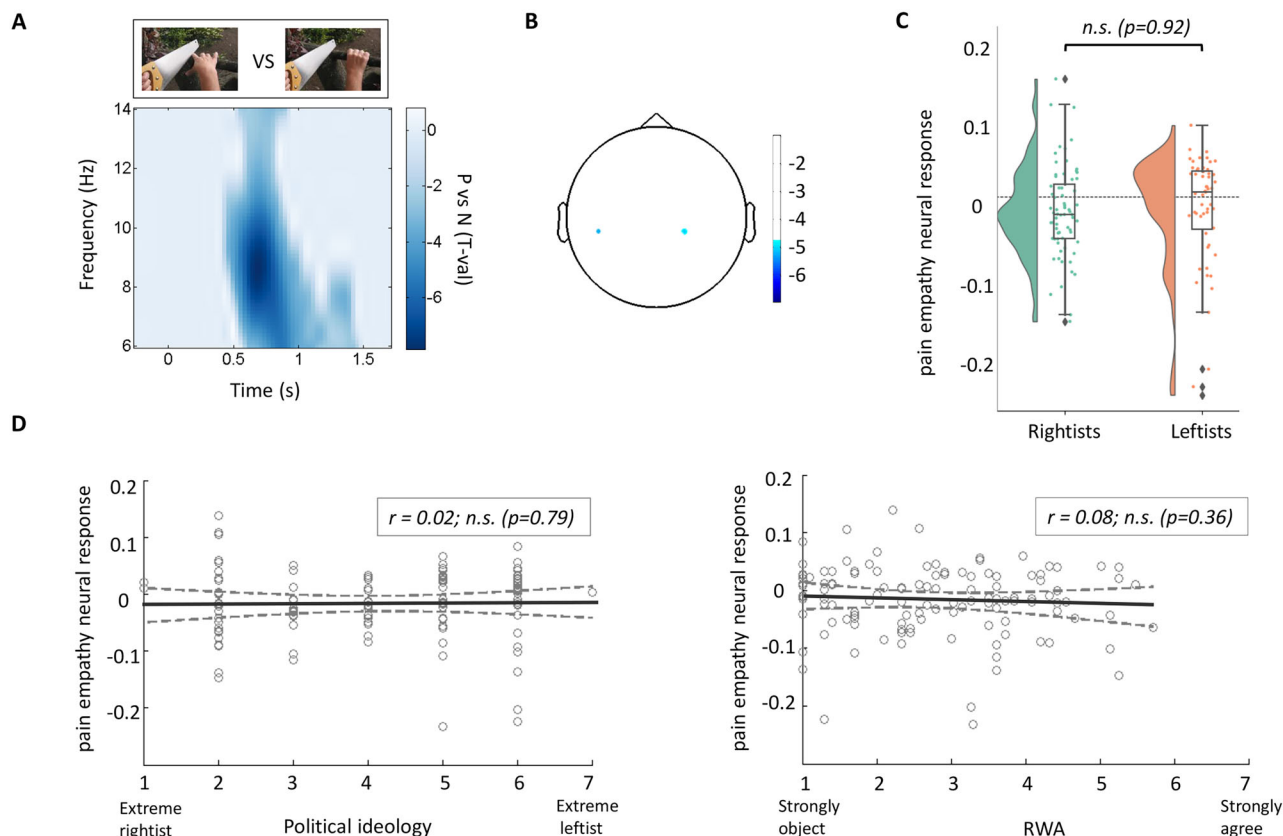
Figure 1. Pain empathy—the neural response. *A*, TFR (bottom panel) of the pain empathy contrast pain versus no-pain (see top left image for stimulus example). *B*, Topographic MEG sensor representation of the same pain empathy contrasts each dataset (compare SI). *C*, Raincloud histograms of pain empathy (extracted from TFR representation) per each political group *D* Parametric representation of pain empathy as a function of political ideology self-reports (left panel) and right-wing authoritarianism ratings (right panel).
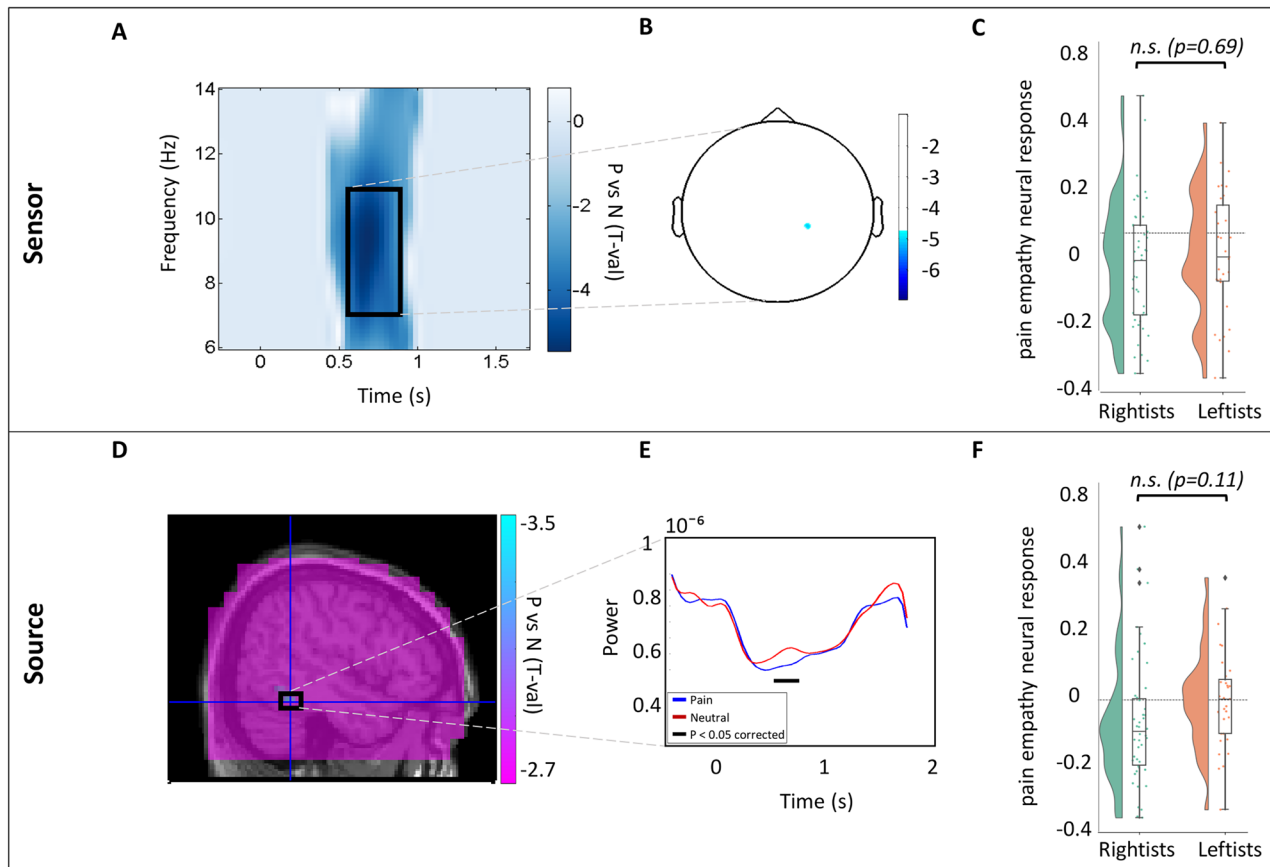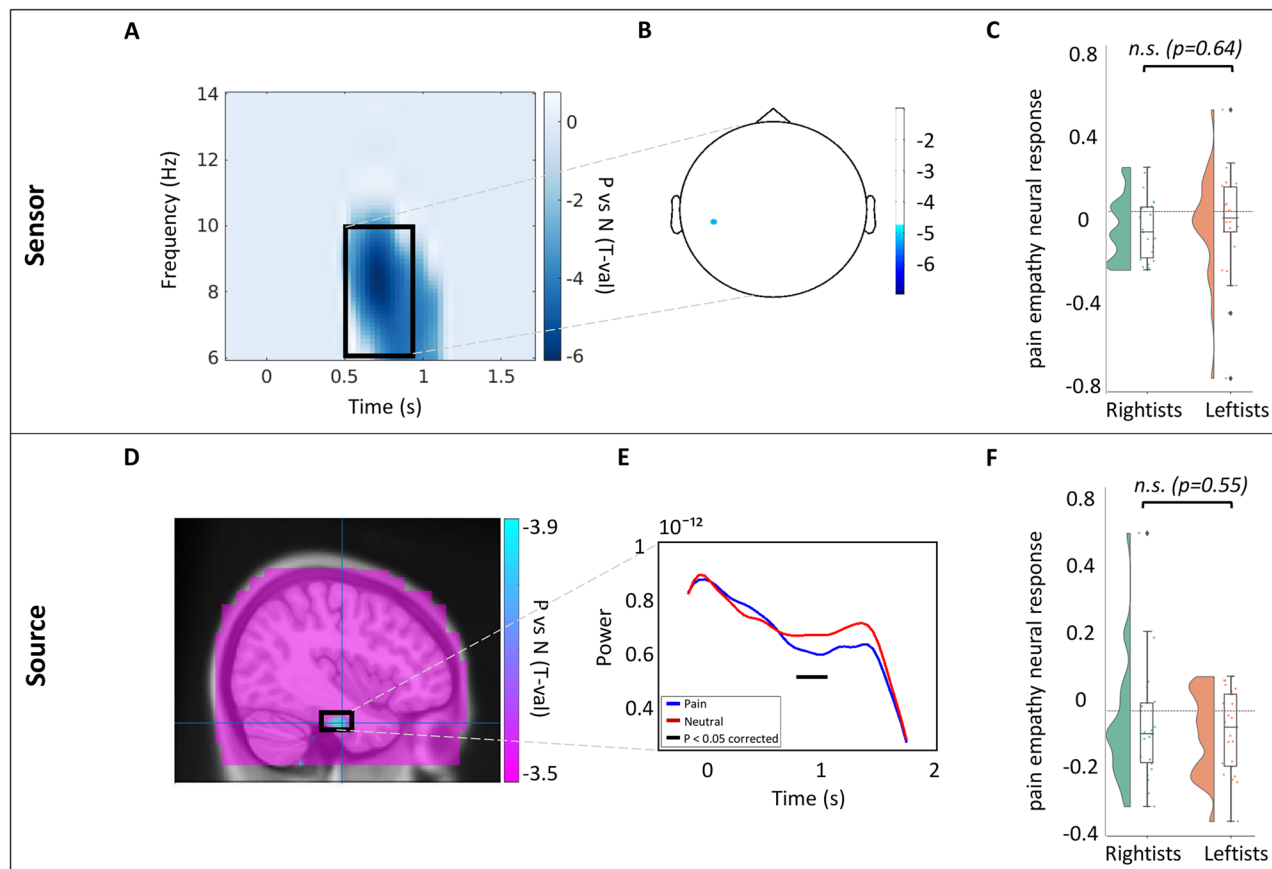
Figure 2. A, TFR of statistical contrast between the two conditions on 77 subjects. **B**, Topographic representation of the most suppressed sensor. **C**, Raincloud histogram, indicating alpha power change ratio in each political group, calculated on the peak sensor and averaged over the significant TF window. **D**, Sagittal view of alpha suppression peak source in the brain, detected by beamforming technique. **E**, Alpha power temporal changes on peak source in both conditions. **F**, Raincloud histogram, indicating VC power ratio in each political group, averaged over the significant TF window.

frequencies, time points, and channels for this permutation test were 9, 41, and 1, respectively. This significant alpha suppression at the sensor level during the physical pain empathy task may imply a possible pain empathy effect in this population. We selected this TF window ($F = 7{-}11$ Hz; $T = 600{-}850$ ms) based on the power statistics and conducted further analysis on this window. The black rectangle in Figure 2A represents the selected TF window that has been used for further analysis. The illustrated peak sensor in Figure 2B was detected by averaging over the selected TF window. To evaluate the difference between the groups, we first examined this contrast at the sensor level. As shown in Figure 2C, the contrast of alpha power changes in the detected peak coordinate between the two groups was not significant ($p = 0.69$; independent T test), and Bayes factor ($BF = 0.25$) showed moderate support for the null hypothesis. To examine the source of alpha suppression in the brain, we conducted beamforming analysis on the selected TF window with the peak frequency at 9 Hz and 5% regularization. Figure 2D represents the significant source found at the right inferior temporal cortex (negative $p_{\text{cluster-cor}} = 0.004$; $T = -3.5$; permutation test). The number of frequencies, time points, and channels for this permutation test were 5, 6, and 1, respectively. To evaluate the alpha power temporal changes in response to the physical pain and neutral conditions, we conducted virtual channel ROI analysis on the peak coordinate extracted from the beamforming analysis on peak frequency (9 Hz) and over the whole time range. As illustrated in Figure 2E, a significantly greater suppression in response to physical pain compared with neutral stimuli was found (negative $p_{\text{cluster-cor}} = 0.012$; $T = -3.1$; permutation test). The virtual channel analysis enabled the evaluation of contrast in alpha power changes over time at the source level between the two political groups. Similar to the sensor level, the difference between the alpha power changes between rightists and leftists, shown in Figure 2F, was statistically nonsignificant ($p = 0.11$; independent T test), and Bayesian analysis showed anecdotal support in null hypothesis ($BF = 0.75$).

Study 2

The whole-brain sensor analysis (contrasting the two conditions) on 47 subjects within the alpha range, depicted in Figure 3A, represents a significant decrease in alpha power (negative $p_{\text{cluster-cor}} = 0.006$; $T = -5.9$; permutation test). The number of frequencies, time points, and channels for this permutation test were 9, 41, and 1, respectively. This significant alpha suppression may indicate an effect in this population in response to pain empathy stimuli. To examine

Figure 3. TFR of statistical contrast between the two conditions on 47 subjects. **B**, Topographic representation of the most suppressed sensor. **C**, Raincloud histogram, indicating alpha power change ratio in each political group, calculated on the peak sensor and averaged over the significant TF window. **D**, Sagittal view of alpha suppression peak source in the brain, detected by beamforming technique. **E**, Alpha power temporal changes on peak source in both conditions. **F**, Raincloud histogram, indicating VC power ratio in each political group, averaged over the significant TF window.

the source of the suppression pattern, we first checked the source on the peak TF window based on the power statistics ($F = 7$–9 Hz; peak frequency $= 8$ Hz; $T = 650$–900 ms) and with 5% regularization, but no significant source was identified within this specific TF window (negative $p_{cluster-cor} = 1$; $T = -3.7$; permutation test). However, looking at the overall 124 subjects' time range and wider frequency range ($F = 6$–10 Hz; peak frequency $= 8$ Hz; $T = 500$–900 ms) and without regularization provided a close to significant result (negative $p_{cluster-cor} = 0.08$; $T = -4.85$; permutation test), which should be considered with caution. The number of frequencies, time points, and channels for this permutation test were 5, 9, and 1, respectively. The black rectangle in Figure 3A shows the latter TF window that has been used for further analysis. Figure 3B indicates the peak sensor over the averaged TF window, and Figure 3C represents the power contrast values between the two conditions in this peak sensor for subjects in each political group with no significant difference ($p = 0.64$; independent T test), and Bayesian factor ($BF = 0.32$) showed moderate support for the null hypothesis, claiming there is no political differences. As illustrated in Figure 3D, the alpha suppression emanates from the source at the left inferior temporal region. Further virtual channel ROI analysis on the peak source coordinate at the peak frequency (8 Hz) and over the whole time range (Fig. 3E) indicates a significantly greater suppression in the physical pain versus neutral conditions (negative $p_{cluster-cor} = 0.012$; $T = -2.65$; permutation test). Similar to the sensor-level results, Figure 3F represents the statistically non-significant difference in alpha power changes between individuals in two opposing political groups ($p = 0.55$; independent T test). The Bayesian factor of this nonsignificant effect is a mild–moderate evidence supporting the null hypothesis ($BF = 0.34$).

After conducting the source analysis in each dataset separately, we used the single value extracted for each subject and evaluated the correlation between the source power values for all 124 subjects and both political-related ratings. The correlation between the source level results and both political ideology rating ($r = 0.04$; $p = 0.66$) and RWA rating ($r = 0.003$; $p = 0.97$) were statistically nonsignificant.

Between political groups analysis

We further examined the contrast between the political groups over the whole TF range ($F = 1$–40 Hz; $T = 0$–2 s) once for all 124 subjects together at the sensor level and then for the data in each study separately, at both sensor and source

levels. The comparisons at the sensor level were done over all sensors and the whole time range and showed nonsignificant differences for all subjects (negative $p_{\text{cluster-cor}} = 0.7$; positive $p_{\text{cluster-cor}} = 0.5$; permutation test), for Study 1 (negative $p_{\text{cluster-cor}} = 0.4$; positive $p_{\text{cluster-cor}} = 0.9$; permutation test) and Study 2 (negative $p_{\text{cluster-cor}} = 0.6$; positive $p_{\text{cluster-cor}} = 0.2$; permutation test). Besides, for each dataset, we averaged over the small TF window to check whether any significant sensors are different between groups but we have not found any sensor neither in Study 1 nor Study 2. Similarly, the contrast between the two political groups at the source level was statistically nonsignificant for Study 1 (negative $p_{\text{cluster-cor}} = 0.1$; positive $p_{\text{cluster-cor}} = 1$; permutation test) and for Study 2 (negative $p_{\text{cluster-cor}} = 1$; positive $p_{\text{cluster-cor}} = 0.1$; permutation test).

Behavioral analysis

As explained in the Materials and Methods section, VPQ and IRI scales evaluate the perception of vicarious pain and trait empathy, respectively. In the VPQ scale, one measure evaluates the intensity of pain (VPQ 1), and the other measure examines the associated discomfort while watching the stimuli (VPQ 2). In the IRI scale, the evaluation was done for EC and PT measures. The statistical details for these measures in each study are provided in Table 1.

In the next step, the interplay between these measures and neural findings (behavioral–neural analysis) and their contrast among political groups (behavioral–political analysis) were evaluated.

Behavioral–neural analysis

We correlated each of these self-reported findings with neural results (the contrast between the conditions) at both sensor and source levels. For the sensor-level neural results, the correlation was only significant with one measure, the neural(sensor)-VPQ 2 ($r = -0.22$; $p_{\text{FDR-cor}} = 0.02$) and not with the other measures as follows: neural(sensor)-VPQ 1 subscale ($r = -0.13$; $p = 0.16$), neural(sensor)-IRI EC ($r = 0.02$; $p = 0.82$) and neural(sensor)-IRI PT ($r = -0.05$; $p = 0.57$). For the source-level neural results, no significant correlation was found between them and self-reported finding neural(source)-VPQ 1 ($r = -0.12$; $p = 0.22$), neural(source)-VPQ 2 ($r = -0.14$; $p = 0.14$), neural(source)-EC ($r = -0.03$; $p = 0.72$) or neural(source)-PT ($r = -0.01$; $p = 0.9$) subscales. These results may indicate that neural measure is more related to behavioral real-life measures of sensitivity to vicarious pain (measured by VPQ) as a correlation detected for neural-V, rather than self-reported trait empathy (measured by IRI). In addition, for the Finnish dataset, we evaluated the correlation between alpha suppression at the peak coordinate and the self-reported ratings of pain stimuli and the correlation was significant ($r = -0.3$; $p = 0.44$).

Behavioral–political analysis

To examine the behavioral contrast between the two opposing political groups, we conducted an independent t test between political groups on the VPQ and IRI subscales for all 124 subjects. Figure 4 represents the contrast between the political groups for each VPQ and IRI subscales. Similar to the neural results, none of the VPQ (VPQ1: $p = 0.15$, mean = 2.33, SEM = 0.21; VPQ2: $p = 0.10$, mean = 4.66, SEM = 0.19) and IRI [IRI(EC): $p = 0.08$, mean = 5.8, SEM = 0.08; (IRI(PT): $p = 0.13$, mean = 5.6, SEM = 0.08] contrasts were statistically significant. In addition, for the Finnish dataset, we calculated the contrast of self-reported ratings of pain stimuli between the two political groups and it was not significant ($p = 0.22$; mean = 2.12; SEM = 0.136).

Additionally, the correlation between political-related ratings and behavioral empathy measures was evaluated. The correlation between the political ideology rating and all four behavioral measures was statistically nonsignificant: VPQ 1 ($r = -0.17$; $p = 0.08$), VPQ 2 ($r = 0.12$; $p = 0.21$), EC ($r = 0.16$; $p = 0.07$), and PT ($r = 0.05$; $p = 0.58$). Similarly, the correlation between the RWA rating and VPQ 1 ($r = -0.01$; $p = 0.94$), EC ($r = -0.01$; $p = 0.95$), and PT ($r = 0.01$; $p = 0.89$) were statistically nonsignificant. For VPQ 2, there was a weak negative correlation ($r = -0.21$; $p_{\text{uncorrected}} = 0.03$), but it did not survive FDR correction. These correlations are consistent with what is found in Figure 4 and indicate that the behavioral measures are not affected by political affiliation and RWA.

Discussion

The current study set out with the aim of assessing the association of individuals' political ideology and psychological traits, particularly empathy toward vicarious physical pain, using both neuroimaging and self-reported measures in a diverse sample. The past two decades have seen the emergence of a lively debate about ideological asymmetries in psychological processes (Brandt et al., 2014a; Jost, 2017). Our study contributes a new understanding to this debate, from the outlook of two relatively separate sets of literature.

Table 1. Statistical details for each self-reported measure in each dataset

	Study 1				Study 2			
	VPQ 1	VPQ 2	IRI (EC)	IRI (PT)	VPQ 1	VPQ 2	IRI (EC)	IRI (PT)
Cronbach's α	0.94	0.89	0.75	0.78	0.97	0.91	0.78	0.72
Mean	2.20	4.09	5.83	5.70	2.50	5.44	5.74	5.44
Standard deviation	2.21	1.90	0.90	0.99	2.58	2.27	0.87	0.75
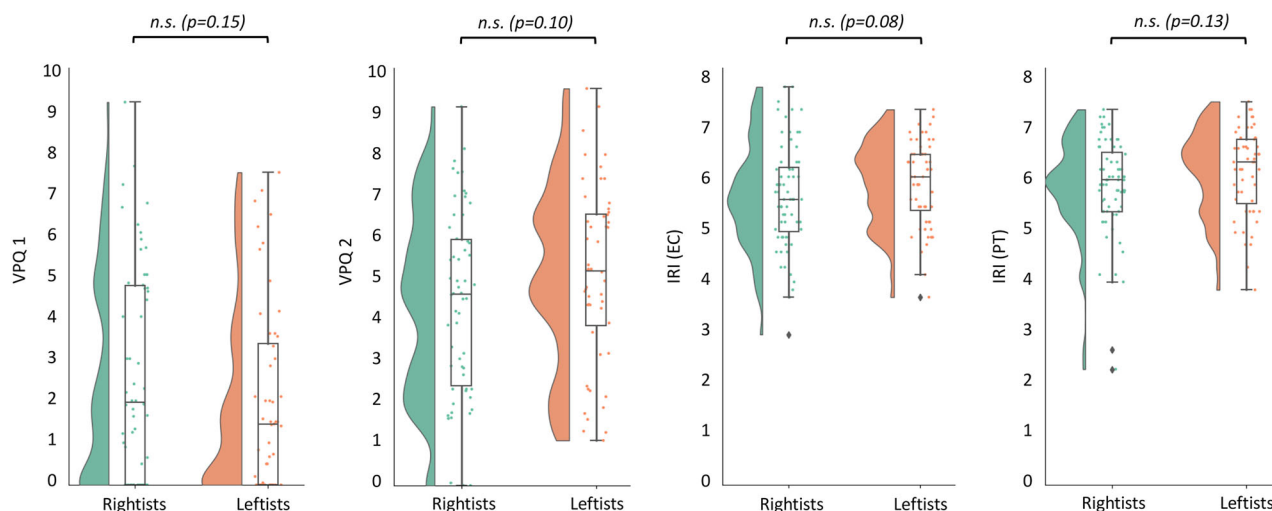
Figure 4. Pain empathy—the behavioral and self-reported measures. This indicates the contrast of behavioral (VPQ) and self-reports (IRI) measures of empathy in the two opposing political groups, all provided nonsignificant contrast V: $p = 0.15$, mean = 2.33, SEM = 0.21; V: $p = 0.10$, mean = 4.66, SEM = 0.19; IRI(EC): $p = 0.08$, mean = 5.8, SEM = 0.08 and IRI(PT): $p = 0.13$, mean = 5.6, SEM = 0.08.

First, in that broad domain of research, what has drawn particular interest was the investigation of whether political ideologies can be explained by biopsychological traits; to investigate this, a series of studies have mainly centered on the neural and physiological responses to images depicting vicarious pain, disgust or the sensation of threat (Thorisdottir et al., 2007; Oxley et al., 2008; Ahn et al., 2014; Brandt et al., 2014b; Bakker et al., 2020; Smith and Warren, 2020; Jost, 2021). The pioneering study in this line was conducted by Oxley et al. (2008), who discovered a potential association between political attitudes and physiological sensitivities to sudden sounds and threatening visual stimuli (Oxley et al., 2008). Their investigation suggested that individuals with lower sensitivity to such stimuli may exhibit a greater inclination toward endorsing liberal immigration policies and conversely, those with higher physiological reactivity to these stimuli display a tendency for increased defense expenditure and expressions of patriotism (Oxley et al., 2008). Similarly, Ahn et al. employed neuroimaging and machine-learning techniques to examine this association and posited that neural responses to emotionally evocative nonpolitical stimuli (i.e., disgusting stimuli) can be highly predictive of political orientation (Ahn et al., 2014). However, in 2020, Bekker and colleagues failed to replicate the results of the Oxley et al. study and did not find any evidence to support the claim that conservatives have stronger physiological responses to threats than liberals (Bakker et al., 2020). Likewise, Brandt et al. challenged the assumption that liberals and conservatives are fundamentally different in their psychological responses to threatening stimuli and proposed an alternative perspective, indicating both ideological groups react in similar ways to such stimuli (Brandt et al., 2014b). In addition, in a recent comprehensive review, Smith and colleagues assessed the empirical records concerning the connection between political beliefs and individual differences in sympathetic nervous system (SNS) activity in response to disgusting and threatening stimuli and found mixed empirical evidence (Smith and Warren, 2020). Overall, the interplay between political inclination and individual psychophysiological traits remains inconclusive, and consequently, the generalizability of the findings comes into question, prompting the need for further empirical exploration and using a more accurate and objective measurement approach to understand this association, as suggested by Smith and Warren.

In the current study, we examined this association by collecting both neuroimaging and behavioral data in two distinct countries. Both datasets in this study utilized stimuli portraying physical pain experienced in the protagonist's body part, enabling shared affective and sensory responses in the observer. The investigation of vicarious physical pain shares similarities with the investigation of disgust and threat (relying on the International Affective Picture System) which was used in some of the studies cited above (Oxley et al., 2008; Ahn et al., 2014; Bakker et al., 2020; Smith and Warren, 2020). The response to observing the stimuli was examined at the sensor level for both datasets together and separately and at the sensor and source levels for each dataset. The neural result was evaluated by inspecting alpha power changes in the time window of 0–2 s after stimulus onset. Previous EEG/MEG studies on pain empathy have consistently demonstrated alpha power suppression within a few hundred milliseconds after stimulus onset (Perry et al., 2010; Whitmarsh et al., 2011; Motoyama et al., 2017; Levy et al., 2018; Zebarjadi et al., 2021; Zebarjadi and Levy, 2023). For example, these studies observed significant alpha suppression in the sensory cortices when participants viewed pain-related images compared with nonpain images. They proposed that, according to the "gating to inhibition" hypothesis, alpha power suppression plays a disinhibitory role in brain regions involved in empathetic responses. The source of the alpha suppression pattern reflecting physical pain empathy was detected in the inferior temporal region, previously shown to be activated while perceiving human body parts and making self/other distinctions (Hooker et al., 2010). Occipitotemporal involvement in pain empathy has also been identified in a previous meta-analysis of fMRI studies (Fallon et al., 2020). However, it is

important to note that MEG has limitations in source localization, as it relies on the beamforming technique to identify the source of brain activity. Furthermore, to our knowledge, there is no meta-analysis of MEG studies on pain empathy, but rather of fMRI studies. These factors may explain why the detected source appears slightly more anterior than reported in the aforementioned meta-analysis. Nonetheless, the consistent detection of this source across both Study 1 and Study 2, using different MEG systems and populations, provides strong evidence that the observed contrast taps the empathy process. By splitting the subjects into two opposing political groups, we detected no asymmetry in pain empathic response at the sensor or source level. Additionally, Bayesian factors calculated and supported the null hypotheses in an anecdotal to moderate level. Consistency of the findings—nonsignificant effect and BF < 1 across all analyses—further support the null hypothesis claim that there is no effect in this task between the two groups. This finding provides new insights into the role of political ideology in the empathy level of individuals and contributes to ongoing debates on the association between political ideology and psychological traits. It is in agreement with the studies indicating ideological symmetry in psychological responses to threatening or disgusting stimuli (Brandt et al., 2014b; Bakker et al., 2020) and supports an earlier study by Brandt et al. suggesting a complex but solvable relationship between political ideology and psychological traits (Brandt and Bakker, 2022).

The second set of literature comes from the fields of political and social psychology. Recent literature has presented contradictory findings about the link between empathy and political ideology (Wagaman and Segal, 2014; Waytz et al., 2016; Hasson et al., 2018; Morris, 2020; Casey et al., 2023; Zebarjadi et al., 2023). A number of these investigations suggested a heightened empathy level within the leftist group in comparison with the rightist group (Wagaman and Segal, 2014; Hasson et al., 2018; Morris, 2020), while others failed to detect similar outcome (Waytz et al., 2016; Casey et al., 2023). However, the majority of these studies relied on self-reported questionnaires to examine the empathy level, with only one recent study employing an objective measure, namely, neuroimaging, to assess the level of empathy (Zebarjadi et al., 2023). Similar to the latter study, we employed neuroimaging, i.e., MEG, to evaluate empathy level in the current study. Howbeit, the finding in the present research is contrary to earlier research suggesting a neural asymmetry in empathic response to vicarious emotional suffering among leftists and rightists (Zebarjadi et al., 2023). A possible explanation for this discrepancy might be that in the earlier study (Zebarjadi et al., 2023), participants were exposed to a paradigm that was based on stories and pictures of people in emotional situations and instructed to mentalize with the stories. The neural marker of empathy to vicarious emotional suffering was identified in the TPJ region, a brain area consistently associated with Theory of Mind and perspective-taking (Lamm et al., 2011). Given that mentalizing ability or tendency might vary among individuals with different ideological foundations and values stronger TPJ activation in the leftist group compared with the rightist group may be linked to differences in their perspective on the social world. In contrast, the stimuli in the current study depict pain in body parts, which is less influenced by the observer's ideological values. Besides, it might induce an internal threat rather than a collective threat that may possibly be relevant to right-wing attitudes (Onraet et al., 2013). The difference in the neural mechanism underlying various types of empathy is in agreement with the prior findings indicating distinct brain networks involved in emotional empathy (linking to mentalizing or sadness), versus physical pain empathy (linking to sensations of disgust or perceiving threat; Lamm et al., 2011; Bruneau et al., 2012). This and other studies indicated that the engagement of various empathy components may vary depending on the stimuli eliciting empathic responses (Lamm et al., 2011; Bruneau et al., 2012). For instance, the meta-analysis by Lamm et al. (2011) highlighted distinct brain regions activated during empathy depending on the type of experimental paradigm. They discussed that images of body parts in painful situations activate neural structures involved in understanding and predicting the outcomes of these situations, thereby triggering inferences about their affective consequences. In contrast, stimuli associated with TOM elicit inferences about self- and other-related social information and facilitate the sharing of other's state based on one's own prior experiences and knowledge (Lamm et al., 2011). The current results suggest that the previously reported findings on the greater level of empathy in leftists compared with the rightists may apply to a distinct type of empathy and may not be generalized to other manifestations of empathy. In addition, contrary to previous self-reported studies (Wagaman and Segal, 2014; Hasson et al., 2018), the evaluation of self-reported data in the current research revealed no differences in trait and state empathy between the two political groups. Nonetheless, with a smaller sample size in this study compared with the previous self-reported studies, caution must be applied. It is also important to note that the detected null results in the current study might not necessarily indicate the absence of difference between the political groups, and future research with higher statistical power and sample variability may further explore this point. Furthermore, neural–behavioral analysis indicated a weak correlation between sensor neural results and one of the VPQ measures, whereas nonsignificant correlations were found between this neural finding and IRI measures. This may suggest that the neural measures are more closely associated with behavioral real-life sensitivity to vicarious pain rather than with self-reported trait empathy. However, no significant correlation was found between the source neural findings and behavioral or self-reported measures which might be due to the limitations imposed by the MEG measurement or lower sample size compared with the psychological studies, as reported in the previous research (Whitmarsh et al., 2011; DiGirolamo et al., 2019). In this study, self-reported vicarious pain ratings has not been measured for the Israeli dataset and are suggested to be incorporated in future research to provide further correlational analysis between the neural findings and self-reported pain response to the same stimuli. Moreover, a cross-national investigation by Malka et al. (2014) demonstrated a stronger link between personality traits and social conservatism in ideologically constrained nations (Malka et al., 2014). To account for cultural disparities, data for the

current research was gathered in two distinct countries, Finland and Israel. The neural and behavioral outcomes demonstrated consistency across both populations, affirming the generalizability of the findings beyond a specific political context. Yet, it is noteworthy that the political dimension might slightly vary in different social contexts (e.g., liberal–conservative dimension is commonly used in the United States instead of the left–right dimension), and the results should be interpreted with caution. Despite the limitations, the combined evidence from neural and behavioral investigations, along with our recent study (Zebarjadi et al., 2023), addresses a point that was overlooked thus far (Wagaman and Segal, 2014; Waytz et al., 2016; Hasson et al., 2018; Morris, 2020; Casey et al., 2023): It provides a unique perspective on the interaction between empathy and political ideology by examining different subcomponents of empathy and the neural response that they trigger. It underscores the complexity of this association, emphasizing the importance of considering targeted components of empathy, societal contexts, and unbiased measurement approaches, such as neuroimaging techniques, when assessing empathic responses. Moreover, it enriches the ongoing debate regarding the relationship between political ideology and psychological traits (e.g., susceptibility to threat, disgust or pain) by further consolidating the recent view of ideological symmetry (Oxley et al., 2008; Ahn et al., 2014; Brandt et al., 2014b; Bakker et al., 2020; Smith and Warren, 2020) in vicarious pain perception. We would like to end with a note that sometimes null findings can be very informative and insightful for science.

References

Ahn WY, et al. (2014) Nonpolitical images evoke neural predictors of political ideology. Curr Biol 24:2693–2699.

Altemeyer B (1983) *Right-wing authoritarianism*. Winnipeg: Univ. of Manitoba Press.

Bakker BN, Schumacher G, Gothreau C, Arceneaux K (2020) Conservatives and liberals have similar physiological responses to threats. Nat Hum Behav 4:613–621.

Brandt MJ, Bakker BN (2022) The complicated but solvable threat-politics relationship. Trends Cogn Sci 26:368–370.

Brandt MJ, Reyna C, Chambers JR, Crawford JT, Wetherell G (2014a) The ideological-conflict hypothesis: intolerance among both liberals and conservatives. Curr Dir Psychol Sci 23:27–34.

Brandt MJ, Wetherell G, Reyna C (2014b) Liberals and conservatives can show similarities in negativity bias. Behav Brain Sci 37:307.

Bruneau EG, Pluta A, Saxe R (2012) Distinct roles of the 'shared pain' and 'theory of mind' networks in processing others' emotional suffering. Neuropsychologia 50:219–231.

Casey JP, Vanman EJ, Barlow FK (2023) Empathic conservatives and moralizing liberals: political intergroup empathy varies by political ideology and is explained by moral judgment. Pers Soc Psychol Bull 01461672231198001.

Davis MH (1983) Measuring individual differences in empathy: evidence for a multidimensional approach. J Pers Soc Psychol 44:113.

DiGirolamo MA, Simon JC, Hubley KM, Kopulsky A, Gutsell JN (2019) Clarifying the relationship between trait empathy and action-based resonance indexed by EEG mu-rhythm suppression. Neuropsychologia 133:107172.

Fallon N, Roberts C, Stancak A (2020) Shared and distinct functional networks for empathy and pain processing: a systematic review and meta-analysis of fMRI studies. Soc Cogn Affect Neurosci 15:709–723.

Gramfort A, et al. (2013) MEG and EEG data analysis with MNE-Python. Front Neurosci 7:267.

Grice-Jackson T, Critchley HD, Banissy MJ, Ward J (2017) Common and distinct neural mechanisms associated with the conscious experience of vicarious pain. Cortex 94:152–163.

Hasson Y, Tamir M, Brahms KS, Cohrs JC, Halperin E (2018) Are liberals and conservatives equally motivated to feel empathy toward others? Pers Soc Psychol Bull 44:1449–1459.

Hooker CI, Verosky SC, Germine LT, Knight RT, D'Esposito M (2010) Neural activity during social signal perception correlates with self-reported empathy. Brain Res 1308:100–113.

Jensen O, Mazaheri A (2010) Shaping functional architecture by oscillatory alpha activity: gating by inhibition. Front Hum Neurosci 4:186.

Jost JT (2017) Ideological asymmetries and the essence of political psychology. Polit Psychol 38:167–208.

Jost JT (2021) *Left and right: the psychological significance of a political distinction*. New York: Oxford University Press.

Lamm C, Batson CD, Decety J (2007) The neural substrate of human empathy: effects of perspective-taking and cognitive appraisal. J Cogn Neurosci 19:42–58.

Lamm C, Decety J, Singer T (2011) Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. Neuroimage 54:2492–2502.

Levy J, Goldstein A, Influs M, Masalha S, Zagoory-Sharon O, Feldman R (2016) Adolescents growing up amidst intractable conflict attenuate brain response to pain of outgroup. Proc Natl Acad Sci U S A 113:13696–13701.

Levy J, Goldstein A, Pratt M, Feldman R (2018) Maturation of pain empathy from child to adult shifts from single to multiple neural rhythms to support interoceptive representations. Sci Rep 8:1–9.

Malka A, Soto CJ, Inzlicht M, Lelkes Y (2014) Do needs for security and certainty predict cultural and economic conservatism? A cross-national analysis. J Pers Soc Psychol 106:1031.

Manganelli Rattazzi AM, Bobbio A, Canova L (2007) A short version of the right-wing authoritarianism (RWA) scale. Pers Individ Dif 43:1223–1234.

Maris E, Oostenveld R (2007) Nonparametric statistical testing of EEG- and MEG-data. J Neurosci Methods 164:177–190.

Morris SG (2020) Empathy and the liberal-conservative political divide in the US. J Soc Polit Psychol 8:8–24.

Motoyama Y, Ogata K, Hoka S, Tobimatsu S (2017) Frequency-dependent changes in sensorimotor and pain affective systems induced by empathy for pain. J Pain Res 10:1317.

Onraet E, Van Hiel A, Dhont K, Pattyn S (2013) Internal and external threat in relationship with right-wing attitudes. J Pers 81:233–248.

Oostenveld R, Fries P, Maris E, Schoffelen J-M (2011) Fieldtrip: open source software for advanced analysis of MEG, EEG, and invasive electrophysiological data. Comput Intell Neurosci 2011:1–9.

Oxley DR, Smith KB, Alford JR, Hibbing MV, Miller JL, Scalora M, Hatemi PK, Hibbing JR (2008) Political attitudes vary with physiological traits. Science 321:1667–1670.

Perry A, Bentin S, Bartal IB-A, Lamm C, Decety J (2010) "Feeling" the pain of those who are different from us: modulation of EEG in the mu/alpha range. Cogn Affect Behav Neurosci 10:493–504.

Pliskin R, Bar-Tal D, Sheppes G, Halperin E (2014) Are leftists more emotion-driven than rightists? The interactive influence of ideology and emotions on support for policies. Pers Soc Psychol Bull 40:1681–1697.

Pratt M, Goldstein A, Levy J, Feldman R (2016) Maternal depression across the first years of life impacts the neural basis of empathy

in preadolescence. J Am Acad Child Adolesc Psychiatry 56:20–29.e3.

Schreiber D (2017) Neuropolitics: twenty years later. Politics Life Sci 36:114–131.

Schubring D, Schupp HT (2021) Emotion and brain oscillations: high arousal is associated with decreases in alpha- and lower beta-band power. Cereb Cortex 31:1597–1608.

Smith KB, Warren C (2020) Physiology predicts ideology. Or does it? The current state of political psychophysiology research. Curr Opin Behav Sci 34:88–93.

Thorisdottir H, Jost JT, Liviatan I, Shrout PE (2007) Psychological needs and values underlying left-right political orientation: cross-national evidence from Eastern and Western Europe. Public Opin Q 71:175–203.

Wagaman MA, Segal EA (2014) The relationship between empathy and attitudes toward government intervention. J Soc Soc Welfare 41:91.

Waytz A, Iyer R, Young L, Graham J (2016) Ideological differences in the expanse of empathy. In: *Social psychology of political polarization* (Valdesolo P, Graham J, eds), pp 61–77. New York: Routledge/Taylor & Francis Group.

Weisz E, Cikara M (2021) Strategic regulation of empathy. Trends Cogn Sci 25:213–227.

Whitmarsh S, Nieuwenhuis ILC, Barendregt H, Jensen O (2011) Sensorimotor alpha activity is modulated in response to the observation of pain in others. Front Hum Neurosci 5:91.

Zaki J, Ochsner KN (2012) The neuroscience of empathy: progress, pitfalls and promise. Nat Neurosci 15:675–680.

Zebarjadi N, Levy J (2023) Neural shifts in alpha rhythm's dual functioning during empathy maturation. Brain Behav 13:e3110.

Zebarjadi N, Adler E, Kluge A, Jääskeläinen IP, Sams M, Levy J (2021) Rhythmic neural patterns during empathy to vicarious pain: beyond the affective-cognitive empathy dichotomy. Front Hum Neurosci 15:380.

Zebarjadi N, Adler E, Kluge A, Sams M, Levy J (2023) Ideological values are parametrically associated with empathy neural response to vicarious suffering. Soc Cogn Affect Neurosci 18: nsad029.