Distinguishing the role of positivity bias, cognitive impairment and emotional reactivity in the deontological preference in multiple sclerosis during moral dilemmas: a social cognition study protocol

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Study protocol

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Abstract

Background

Multiple sclerosis (MS) is a chronic inflammatory and neurodegenerative disease of the central nervous system characterized by a broad and unpredictable range of symptoms, including cognitive and sociocognitive dysfunction. Among these social-cognitive functions, moral judgment has been explored in persons with MS (PwMS) using moral dilemmas, where participants must decide whether to sacrifice one person to save a greater number. Opting for such a sacrifice reflects utilitarian reasoning (sacrificing one for the benefit of many is deemed acceptable), while refusing reflects deontological reasoning (such sacrifice is considered morally wrong). Compared to controls, PwMS have been shown to make greater deontological moral choices in such dilemmas.

Objectives

While PwMS have demonstrated a higher tendency for deontological moral choices in moral dilemmas compared to controls, the underlying determinants of this reasoning pattern remain unclear. In this project, we aim to investigate cognitive, emotional, and motivational factors that may explain deontological decision-making in MS.

Methods and analysis

We will recruit a sample of 45 PwMS and 45 controls aged 18–55 years. The type of response, deontological or utilitarian, to a series of 20 vignettes of moral dilemmas will constitute the primary outcomes. Global cognitive performance, temporal perception and emotional reactivity measured by electrodermal activity (EDA) during moral dilemmas will be secondary outcomes.

Ethics and dissemination:

Ethics approval was granted by a national ethical committee (CPP Ouest III, national number 2023-A00447-38). The project is sponsored by the ARSEP Foundation. Findings will be presented at national and international conferences, as well as published in peer-reviewed scientific journals.

What is already known on this topic

Prior research has established that PwMS tend to make more deontological choices in moral dilemmas, reflecting a moral reasoning pattern that differs from healthy controls, yet the underlying factors driving this phenomenon remain unclear.

What this study adds – This study enhances our understanding of the cognitive, emotional, and motivational factors affecting moral decision-making in PwMS by combining subjective moral choices with objective emotional response measures, such as electrodermal activity (EDA).
How this study might affect research, practice or policy – This study aims to enhance both PwMS self-awareness and caregiver comprehension of the decision-making processes employed by PwMS, thereby contributing to the amelioration of their overall quality of life.

BACKGROUND

Multiple sclerosis (MS) is a chronic, inflammatory, autoimmune and demyelinating disease that affects young adults (between 20 and 40 years old) and has a significant impact on patients’ quality of life. The main disorders found in these patients are motor disorders, somesthesia, visual disorders, sexual disorders and chronic fatigue. Among the various symptoms encountered, cognitive disturbances are frequent (40 to 70% of patients [1], appear early and have a major impact on the socio-professional life and quality of life of patients [2, 3]. These disorders are, mainly, impairments in information processing speed (IPS) [4, 5], learning and episodic memory and executive functioning [6]. In addition to cognitive impairments, recent studies have also identified social cognition impairments in PwMS [7, 8]. Social cognition encompasses the processes and knowledge involved in interpersonal interactions. Certain authors have argued that sociocognitive difficulties are likely to coexist with the abovementioned cognitive impairments in PwMS but may also arise independently [9]. One area of social cognition that has been studied is moral judgment, which aims to understand the determinants of moral decision-making, including how and why individuals make moral choices in accordance with societal norms and expectations.

Moral judgment is commonly evaluated through a set of vignettes crafted by Greene and colleagues [10], which portray moral dilemmas. These dilemmas challenge participants to decide whether sacrificing one person is justifiable to save a larger group. Opting for such a sacrifice aligns with utilitarian reasoning, where the end justifies the means (e.g., sacrificing one life to save five is deemed acceptable). On the other hand, rejecting this option reflects deontological reasoning, asserting that sacrificing one to save many is morally wrong. In addition to the choice type (deontological or utilitarian), other commonly included measures in moral judgment assess the level of moral permissibility (with low scores reflecting deontological choice/reasoning), level of emotional reaction to the moral dilemma, and the degree of moral relativity, which gauges/estimates the extent to which others would act similarly (e.g., out of 100 people who responded to the dilemma, how many would respond as I did). In the MS population, research has shown that compared to control subjects, PwMS demonstrate a higher tendency for deontological moral choices in moral dilemmas [11]: They reported lower levels of moral permissiveness, along with an increase in both moral relativity and emotional reactivity [12–14].

Thus, it would appear that PwMS issue more deontological choices (decreased moral permissiveness) than controls. While PwMS seem to exhibit distinct patterns of moral reasoning, with a particular emphasis on deontological reasoning, the underlying factors driving these patterns/contributing to this specific pattern remain unclear. Considering that these patients otherwise exhibit empathy deficits as well as higher alexithymia than the global population [15, 16], these patterns of results are surprising. Indeed,
in other clinical populations, low empathic abilities and high alexithymia are linked to utilitarian rather than deontological moral judgments [17].

**AIMS**

In this project, we aim to investigate motivational, cognitive and emotional factors that may explain deontological decision-making in PwMS.

One possible motivational factor that could explain these findings is the presence of a positivity bias in PwMS. A positivity bias is characterized by a heightened preference for positive emotions at the expense of negative emotions, resulting in a preference for processing positive information over negative information [18]. This phenomenon has been extensively documented in the literature on cognitive aging in healthy individuals and has been shown to result in significant changes in emotional information processing with advancing age [19, 20]. In a meta-analysis of 100 studies [21], the authors report a consistent preference among older adults (compared to younger adults) for positive over negative information from various sources, such as faces [19, 22, 23], labels [24–26], and emotional musical excerpts [27].

Positivity bias may serve as an explanatory factor for the decision-making patterns observed in moral judgments in MS. According to motivational hypotheses presented in the literature, positivity bias is not underpinned by chronological age but rather by motivational changes linked to modifications of future temporal perspectives [19]. If the emergence of a positivity effect is due to motivational changes, it is reasonable to think that various other factors and social contexts may also promote this effect. In fact, the positivity effect has been observed in chronic disease contexts, such as cancer [28–31] and HIV [32]. Similarly, MS, which is the most common chronic disabling neurological condition among young adults, could lead to a shift in patients' personal priorities, goals, and future projections. Supporting this hypothesis in MS, a study [33] showed that patients had a different temporal orientation than controls, focusing more on the present. These findings suggest that a positivity bias may occur in MS patients and be responsible for some neuropsychological symptoms, particularly affecting emotional processing.

In this project, we aim to investigate whether a positivity bias could account for the more deontological decision-making patterns observed in MS [11, 13, 14]. Previous studies have shown that older individuals tend to make more ethical moral judgments than younger adults [34]. Similar results have been observed in young individuals when their time horizons are experimentally restricted [35]. Therefore, our research aims to examine whether the more deontological moral choices made by MS patients can be explained by changes in future temporal perspectives and a positivity bias.

On the cognitive front, the literature has shown that utilitarian judgments demand a higher level of cognitive resources and are thus less likely to occur when individuals are already under cognitive load [36, 37]. Consequently, another potential explanation for the predominantly deontological choices made by PwMS could be an optimization of limited cognitive resources. This hypothesis draws its roots from Greene's dual-process theory (2005). According to Greene [38], moral dilemmas can be categorized into...
two forms: "personal" dilemmas and "impersonal" dilemmas. Personal dilemmas involve the individual directly, presenting a scenario in which a moral rule is breached, leading to physical or emotional harm to others that can be directly attributed to the individual. On the other hand, "impersonal" dilemmas correspond to situations where the individual's decision does not directly cause harm to others. In personal moral dilemmas, "deontological" responses occur much more rapidly than "utilitarian" responses, indicating extremely swift emotional processing. This swift response time is not observed in "impersonal" moral dilemmas, where decision times are significantly longer. This supports the notion of a cognitive process involving the analysis of the costs and benefits of one's actions [10, 39].

Greene et al. (2008) [37] also demonstrated that introducing an interfering task during the resolution of moral dilemmas could lead to an overload of participants' moral decision-making processes, resulting in a decrease in available attentional resources. The decrease in attentional resources caused by overload interfered with the reasoning process and more specifically with utilitarian responses. Thus, there was an increase in the response times associated with these types of judgments. Notably, the findings from Greene's study (2008) indicated that in the "dual task" condition, response times for "utilitarian" choices were longer than those associated with "deontological" choices, which do not necessitate cognitive resources. This study was conducted to provide empirical support for Greene's dual-process theory of moral judgment.

Other researchers have also employed a similar approach to emphasize the influence of cognitive load on moral decision-making. For instance, authors manipulated the time constraints imposed on participants to respond to various moral dilemmas, creating an "under pressure" condition with a mere 8-second response time and a "without pressure" condition allowing 3 minutes for response [40]. The results revealed that in the 8-second response time condition, most participants tended to provide deontological answers. Consequently, the authors concluded that when shorter decision times are enforced, individuals have limited time to engage in the cognitive processes inherent to their judgment, making them more inclined to make "ethical" choices. Based on these findings, it is plausible to hypothesize that cognitive impairments experienced by PwMS could lead to a preference for deontological choices. This preference may arise from the restricted cognitive resources available to them during moral dilemma situations, as demonstrated by the limitations in their cognitive processing abilities.

From an emotional point of view, previous studies have shown that people suffering from MS have higher levels of emotional reactivity than healthy subjects when confronted with moral dilemmas [13, 14, 41]. The literature has pointed out that deontological moral thinking is driven by strong emotional reactions: when emotions are experienced intensely, they are likely to override the decision-making process, resulting in a deontological moral judgment where causing harm is seen as morally wrong [10, 39]. fMRI investigations conducted by Greene et al. (2001, 2004) showed, for example, that "personal" dilemmas elicit stronger emotional reactions as well as more deontological judgments. However, all studies investigating emotional processing in MS have thus far focused exclusively on behavioral measures, with no studies combining these subjective measures with objective measures of the emotional response during a moral judgment task, such as electrodermal response (EDA) [42]. EDA refers to electrical
variations in the skin associated with the functioning of the sweat glands, which are activated by nerve discharges of central origin under the control of the sympathetic nervous system. Numerous studies have demonstrated the usefulness of EDA in cognitive neuroscience, including studies of somatic marker theory and its relation to decision-making [43], behavioral anticipation processes [44], detection of reasoning bias [45], and mental load [46]. Recent research has focused on clarifying the role of EDA in exploring emotional dimensions, as a reliable marker of reticular system functioning. Thus, the amplitude of EDA increases linearly with the estimated intensity of the emotional response and differentially with the valence of the emotional information (pleasant or unpleasant) [47]. Including an objective assessment of emotional reactivity in moral decision-making will provide a fine-grained and novel measure of patients' emotional responses during choices and allow us to determine if PwMS have a higher level of emotional reactivity than controls. We will thus examine whether the higher tendency for deontological moral choices in moral dilemmas is linked to emotional experience in PwMS and more specifically, to a stronger emotional reactivity to moral dilemmas.

METHODS AND ANALYSIS

Objectives

The primary objective of this study is to compare the deontological or utilitarian choices made by patients and control individuals in moral dilemma situations using a set of 20 vignettes from Christensen et al.'s (2014) French-validated battery [48].

Three secondary objectives are associated with this protocol, corresponding to the three explanatory factors investigated (motivational, cognitive-affective, and neurophysiological):

1. To assess whether deontological decision-making preference in PwMS [11] can be attributed to a positivity bias.
2. To investigate the extent to which the presence of cognitive and affective impairments contributes to patients' decision making.
3. To study the extent to which the subjective emotional reactivity recorded during the moral judgment task is associated with objective responses.

Participants

We conducted an a priori power analysis [49], to determine the appropriate sample size for our study. Since our primary endpoint relied on the nature of the choices made in the moral judgment task, specifically the measure of "moral permissiveness," we used the data reported by Realmuto et al. (2019) to estimate the number of participants needed in each group. We aimed to achieve a minimum significance level of $p = .05$ and a power of .95. Based on the analysis of moral choices made in MS patients compared to a matched healthy population, we used the effect size reported in the Realmuto et al. (2019) study of $d= .74$ as an estimate. The analysis showed that we need to recruit at least 41...
participants per group to have a 95% chance of detecting an effect. A safety margin of 10% has been added, so we plan to include 45 participants per group, which increased the chance of detecting the investigated effect to 96.7%.

**Inclusion criteria**

**MS Patient Group**

- Men or women aged 18–55 years.
- MS patient group: diagnosed with relapsing-remitting MS (RRMS) according to the 2010 McDonald criteria [50]
- EDSS score ≤ 4, with no significant motor, cerebellar or somesthesia disorders of the upper limbs, and no visual disorders (specific parameter of EDSS score less than 2) without relapses in the preceding 6 weeks. Fluent in French and able to express themselves clearly.
- Willing and able to understand and sign the informed consent and information letter regarding participation in the study.
- Health insurance coverage.

**Control group:**

- Men or women aged 18–55 years.
- No known overall cognitive impairment and MoCA < 26
- Fluent in French and able to express themselves clearly.
- Willing and able to understand and sign the informed consent and information letter regarding participation in the study.
- Health insurance coverage.

**Exclusion criteria**

**MS Patient group**

- Prior neurological pathology, head injury with loss of consciousness, or psychiatric pathology (apart from stable mild to moderate depressive symptoms)
- Severe general medical conditions that could affect participation in the study
- Perceptual or dysarthric disorders that could interfere with verbal communication or reading
- Severe cognitive impairment with an SDMT score of less than − 2.5 standard deviations
- Severe depressive syndrome with a BDI-FS score > 10
- Visual and auditory impairments that could interfere with neuropsychological testing
- Major cerebellar syndrome or sensitive deficits
Treatment with psychotropic drugs, except for benzodiazepines and hypnotics

Control group

- Prior neurological pathology, head injury with loss of consciousness, or psychiatric pathology (with the exception of stable mild to moderate depressive symptoms)
- Severe general medical conditions that could affect participation in the study
- Perceptual or dysarthric disorders that could interfere with verbal communication or reading
- Cognitive impairment in controls, with a MoCA score < 26
- Severe depressive syndrome with a BDI-FS score > 10
- Visual and auditory impairments that could interfere with neuropsychological testing
- Major cerebellar syndrome or sensitive deficits
- Treatment with psychotropic drugs, except for benzodiazepines and hypnotics

The study will be proposed to eligible participants at Saint Philibert or Saint Vincent de Paul Hospital in the following scenarios: during a routine neurology consultation, during a routine physical medicine and functional rehabilitation consultation or during inpatient hospitalization for disease-modifying therapy administration. Participants will be provided with an information letter explaining the study purpose and procedures, potential benefits and risks, study staff contact information and the consent form. Control subjects matched for sex, sociocultural level and age (+/- 2 years) will be recruited from the general population through a poster campaign.

MATERIAL

Clinical and demographic assessment

The following clinical and demographic data will be collected: age, sex, years of education, laterality, and medical history by an interview preceding the experiment, MS subtype, disease duration, date of the last relapse and current disease-modifying treatment. Physical disability will be assessed using the Expanded Disability Status Scale (EDSS) [51]

Primary outcome measure

The moral judgement task includes 20 moral dilemma vignettes from Christensen et al.’s (2014) French-validated battery [48]. For each vignette, participants will be asked to make a choice between deontological or utilitarian options, which will constitute our primary outcome measure. In addition to the choice type (deontological or utilitarian), other measures will be included (i.e., level of moral permissibility with low scores reflecting deontological choice), level of emotional reaction to the moral dilemma, and the degree of moral relativity, which gauges/estimates the extent to which others would act similarly (e.g., out of 100 people who responded to the dilemma, how many would respond as I did). More details about these measurements can be found in Additional file 1.
Secondary outcomes measures

Cognitive and affective assessment

To investigate how cognitive and affective impairments contribute to patients' decision-making, a routine cognitive and affective assessment will be administered to all patients. The administered tests as part of the cognitive and affective assessment are listed in Table 1, and a detailed description of each test is provided in Additional file 1.
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<thead>
<tr>
<th>Cognitive assessment</th>
<th>Cognitive functions</th>
<th>Measures</th>
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<tr>
<td>BICAMS</td>
<td>Verbal episodic memory</td>
<td>total free recall (/60)</td>
</tr>
<tr>
<td>CVLT</td>
<td>Visuo-spatial episodic memory</td>
<td>total free recall (/12)</td>
</tr>
<tr>
<td>BVMT-R</td>
<td>IPS</td>
<td>Number of correct substitutions</td>
</tr>
<tr>
<td>SDMT</td>
<td>Digit span: Forward (DSF), Backward (DSB), Sequencing (DSS)</td>
<td>Working memory</td>
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<td></td>
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<tr>
<td>SCWT</td>
<td>Inhibition</td>
<td>Time to complete each condition</td>
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<td></td>
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<tr>
<td>TMT</td>
<td>Reactive flexibility</td>
<td>Time to complete each condition</td>
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<td></td>
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<tr>
<td>Verbal fluencies</td>
<td>Spontaneous flexibility</td>
<td>Number of different words.</td>
</tr>
<tr>
<td>PASAT</td>
<td>IPS / working memory</td>
<td>Number of correct responses (/60)</td>
</tr>
</tbody>
</table>

### Affective assessment

<table>
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<tr>
<th>Affective assessment</th>
<th>Affective dimensions</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI-FS</td>
<td>Depression</td>
<td>Score ranging from 0 to 21</td>
</tr>
<tr>
<td>STAI-Y</td>
<td>Anxiety</td>
<td>Score ranging from 20 to 80</td>
</tr>
<tr>
<td>TAS-20</td>
<td>Alexithymia</td>
<td>Score ranging from 0 to 100</td>
</tr>
<tr>
<td>EQ8</td>
<td>Empathy</td>
<td>Score ranging from 0 to 80</td>
</tr>
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</table>

Note: BICAMS, Brief International Cognitive Assessment for Multiple Sclerosis; CVLT: California Verbal Learning Test; BVMT-R: Brief Visuo-spatial Memory Test; SDMT: Symbol Digit Modalities Test; SWCT: Stroop Color-Word Test; TMT: Trail Making Test; PASAT: Paced Auditory Serial Addition Test; BDI-FS: Fast-Screen Beck Depression Inventory; STAI-Y: State Trait Anxiety Inventory.

**Temporal perception assessment**
The assessment of participants' explicit temporal perception will be conducted using the French adaptation of the Future Time Perspective Scale, developed by [52] and adapted by [53]. Participants will rate their level of agreement on 10 items using a 5-point scale ranging from 1 (not at all) to 5 (completely) to assess their future time perspective (e.g., "I plan to set many new goals in the future"). A total score will be calculated. To assess participants' implicit temporal perspective, a word completion task [35] will be used. The task presents participants with 20 gap words that can be completed with either words referring to restricted future time perspective ("target words") or neutral words. For example, the word "COFF _ _" can be completed with "COFFIN" or "COFFEE". The percentage of target words completed will be calculated.

To assess attentional preferences for positive information, also known as positivity bias, a French adaptation of the "Dot Probe Task" [54] will be used. This detection task measures attentional preferences for positive or negative information, allowing the evaluation of whether individuals tend to focus more on positive or negative information.

**Physiological data**

During the moral judgment task, electrodermal responses will be recorded through the Biosignalsplux Researcher® equipment, which is certified for medical research and has been used in previous studies [55–57]. The signal will be recorded at a sampling frequency of 200 Hz using Biosignalsplux Researcher® equipment connected to a computer hosting Biosignalsplux software. The EDA will be collected with two pregelled self-adhesive disposable Ag/AgCl electrodes, filled with an isotonic conductive paste (0.05M NaCl) and placed at the level of the second phalanx of the index and middle fingers of the nondominant hand [47].

The purpose of using this device is to measure the participant’s objective emotional reactivity during the task. The signals recorded by the device will be examined relative to the participant’s own baseline levels (measured without stimulus, i.e., baseline measure), which will serve as a reference for interpreting the signals obtained during the task.

**PROCEDURE**

The experiment will be conducted in a single session, which will last approximately 2.5 hours and will include the administration of a consent form and a demographic questionnaire; a moral judgment task; cognitive tests and affective questionnaires, and tasks to assess temporal perception (FTPS, word completion task).

The experiment will take place in a single session including the following:

a) A clinical and demographic assessment,

b) A cognitive and affective assessment: a full description of the material used is available in supplementary material 1,
c) A moral judgment task: Twenty moral dilemma vignettes from the work of Green et al., 2004 will be presented to the participants. For each scenario, participants must make either a utilitarian choice or a deontological one.

d) A recording of electrodermal response: During the moral judgment task, an electrodermal response recording device will be placed on the participant's nondominant hand using two electrodes to objectively measure emotional reactivity. Prior to starting the moral judgment task, a baseline measurement of the electrodermal response will be taken for one minute while the participant is instructed to relax.

STATISTICAL ANALYSIS

Descriptive

First, we will conduct a description of each group of participants (i.e., MS patients; healthy controls) through the responses provided to the demographic questionnaire, and the cognitive and affective evaluation. For qualitative variables, the size and frequency of each category will be calculated (e.g., number of men and women, number of participants by level of education). For quantitative variables, the mean and standard deviation will be calculated (e.g., age of participants, laterality, and disease duration for PwMS). Additionally, independent samples t-tests—or nonparametric Mann-Whitney U tests when appropriate—will be conducted to analyze group differences in quantitative demographic measures. Group differences on demographic qualitative measures will be analyzed using chi-squared tests.

Group differences in main outcome measures

Regression analyses

We will compare moral choices (deontological vs. utilitarian) between groups using a mixed logistic model, with group (PwMS vs. control) as a between-subjects factor, and the type of scenario (personal vs. impersonal) as a within-subjects factor. Holm's correction will be applied to account for multiple comparisons.

Moderated mediation analysis

We will test the existence of a conditional indirect effect (a moderated-mediation effect). Based on existing literature, we expected attentional preferences for positive information to mediate the relationship between temporal perspective and moral positioning (i.e., the level of moral permissiveness). As we expect an interaction effect between temporal perspective and participant group (PwMS vs. controls), we expect to observe a mediated moderation effect [58]. This means that the influence of the temporal perspective on moral permissiveness should be moderated by the participant group, and this moderation should be mediated by attentional preferences for positive information. Note that this relationship is expected to be observed only for "impersonal" scenarios. This analysis will help to investigate whether patients’ deontological preferences are associated with the emergence of a positivity effect due to restricted temporal perspectives.
Group differences in the second outcome measures

Regression analyses

We will conduct mixed logistic regressions to assess whether cognitive scores predict the type of choice (deontological/utilitarian). This analysis will help to investigate the relationships between decision-making patterns and the level of cognitive disorders in patients.

Correlation analyses

We will first calculate correlations between the subjective and objective levels of emotional reactivity during the moral judgment task (i.e., reported levels versus individuals' EDA) for each type of scenario (personal, impersonal) for patients and controls separately. We will then test the significance of the difference between these two correlations using Fisher's $z$-Test. This analysis will help to investigate whether patients' deontological preferences are associated with increased emotional reactivity.

DISCUSSION AND EXPECTED RESULTS

Based on our study design and hypotheses, we expect to observe a higher frequency of deontological responses to moral dilemmas in PwMS compared to control participants, who are likely to exhibit more utilitarian responses. Additionally, we anticipate the level of cognitive impairment to predict the frequency of deontological responses to the moral dilemma task. This may indicate that patients with cognitive decline rely more heavily on automated decision-making mechanisms. At the same time, we expect the level of emotional arousal to predict the frequency of deontological responses. This finding could indicate that people with higher emotional reactivity tend to rely more on an emotional process than on a cognitive process when faced with a moral dilemma.

Finally, we anticipate a stronger positivity bias in PwMS, indicative of a temporal perception bias. This bias is expected to correlate with an increased frequency of deontological responses in the moral dilemma task, with participants demonstrating a significant positivity bias making deontological choices more often. Consequently, we anticipate the emergence of a significant moderated-mediation effect within the MS group, between temporal perspective, attentional preferences, and moral positioning.

Ethics and dissemination

Ethics approval was granted by a national ethical committee (iCPP: Comité de protection de personnes; CPP Ouest III, national number 2023-A00447-38). The authors confirm that all methods and procedures employed in this research will be conducted, as they were approved, in strict accordance with the relevant guidelines and regulations set forth by the national ethical committee. Informed consent will be approved be obtained from all subjects.

The project is sponsored by the ARSEP Foundation. Findings will be presented at national and international conferences, as well as published in peer-reviewed scientific journals. An independent
scientific evaluation, a subscription to a specific insurance for the study and a justification that the budget to complete the study was already obtained as usually recommended before the statement of the ethical committee.

List Of Abbreviations

<table>
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<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>CPP</td>
<td>“Comité de Protection des Personnes”</td>
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<tr>
<td>EDA</td>
<td>Electrodermal Activity</td>
</tr>
<tr>
<td>EDSS</td>
<td>Expanded Disability Status Scale</td>
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<tr>
<td>IPS</td>
<td>Information Processing Speed</td>
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<tr>
<td>MS</td>
<td>Multiple Sclerosis</td>
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<tr>
<td>PwMS</td>
<td>Persons with MS</td>
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<tr>
<td>RRMS</td>
<td>Relapsing-Remitting MS</td>
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Declarations

Consent for publication

Not applicable

Funding statement

The project is sponsored by the ARSEP Foundation (Grant Number: 2022_1291).

Competing interests’ statement

The authors declare no conflict of interest.

Author contributions

Conceptualization: LZ, BD, BL, AP.

Data curation: BL, JP, MS, AK, CD.

Investigation: LZ, BD, BL, JP, MS, AK, CD.

Methodology: LZ, BD, MS, BL, AP, LN.

Supervision: BD, BL, AP.
Validation: **BD, BL, MS, AP.**

Writing – original draft: **LZ.**

Writing – review & editing: **LZ, BD, BL, AP, JP, MS, AK, CD.**

**Availability of data and materials**

Details of the material are given in Additional file 1. Available data may be obtained on request from the corresponding author.

**References**


54. MacLeod C, Mathews A, Tata P. Attentional Bias in Emotional Disorders.


**Supplementary Files**

This is a list of supplementary files associated with this preprint. Click to download.
• Additionalfile1ZikosetalBMC.docx