Received: 15 April 2022 | Revised: 31 August 2022 | Accepted: 7 September 2022

DOI: 10.1002/ejp.2037

ORIGINAL ARTICLE

EJP European Journal of Pain

Pain and masochistic behaviour: The role of descending modulation

Sophie Baudic | **Frédérique Poindessous-Jazat** | **Didier Bouhassira**

Inserm U987, APHP, UVSQ, Paris-Saclay University, CHU Ambroise Paré, Boulogne-Billancourt, France

Correspondence
Didier Bouhassira, Inserm U987, Centre d'Evaluation et de Traitement de la Douleur, Hôpital Ambroise Paré, 9 avenue Charles de Gaulle, 92100 Boulogne-Billancourt cedex, France.
Email: didier.bouhassira@aphp.fr

Funding information
Inserm

Abstract

Background: The mechanisms of pain perception in individuals with masochistic behaviour (MB) remain poorly documented. We hypothesized that MB is associated with context-specific changes in descending pain modulation.

Methods: We compared the effects of four standardized sets of images with positive (erotic), negative (mutilations), masochistic or neutral emotional valences on the RIII nociceptive reflex evoked by electrical stimulation of the sural nerve and recorded on the ipsilateral biceps femoris in 15 controls and 15 men routinely engaging in MB. We systematically assessed the RIII reflex threshold and recruitment curves (up to the tolerance threshold), thermal (heat and cold) pain thresholds measured on the upper and lower limbs and responses to the pain sensitivity questionnaire, to compare basal pain perception between our two groups of participants. We also assessed anxiety, depression, empathy, alexithymia, high sensation seeking and catastrophizing, to investigate their potential influence on the emotional modulation of pain.

Results: Thermal pain thresholds, RIII reflex recruitment curves, and responses to the psychological and pain sensitivity questionnaires were similar in the two groups. Neutral, positive and negative images modulated the RIII reflex similarly in the two groups. By contrast, masochistic images induced a significant ($p < 0.01$) decrease in RIII reflex responses in subjects with MB, whereas it tended to increase these responses in control subjects.

Conclusions: Our data suggest that psychological profile, basal pain sensitivity and the emotional modulation of pain are normal in individuals with MB but that these subjects selectively engage descending pain inhibition in the masochistic context.

Significance: Decrease pain perception related to masochistic behaviours is associated with specific activation of descending pain inhibition.

1 | INTRODUCTION

The acronym BDSM (bondage and discipline, dominance and submission, sadism and masochism) refers to various sexual practices including physical, psychological and role-play elements involving power exchanges between willing participants (De Neff et al., 2019). BDSM, thus, corresponds to a large range of interactions in which a dominant partner controls the scene and a submissive partner consents to being subjected to the actions of the dominant partner. These interactions frequently involve painful stimuli, even though playing with power relationships is probably just as important as inflicting or receiving pain (Kamping et al., 2016).

Masochistic individuals (i.e. those who are the most exposed to pain in these situations) have variable attitudes towards pain. They gain pleasure from painful stimuli in the context of BDSM interactions but seem to have normal pain perception in everyday life (Dunkley et al., 2020). This suggests that physiological nociceptive mechanisms are normal in subjects with masochistic behaviour (MB), but some studies have reported an increase in pain thresholds in response to experimental stimuli outside the masochistic context in subjects displaying MB (Defrin et al., 2015; Pollok et al., 2010; Wuyts et al., 2021). Another question concerns the way in which subjects with MB process painful stimuli into pleasure in specific contexts. Do they display general or context-specific alterations to the emotional modulation of pain? The answers to these questions may provide new insight into the neural mechanisms underlying pain modulation, but also improve our understanding of some chronic pain syndromes associated with alterations to the emotional modulation of pain (Elsenbruch et al., 2010).

The mechanisms underlying the emotional modulation of pain are incompletely understood, but it has repeatedly been shown that emotions can influence pain perception by acting on descending modulatory systems (Rhudy et al., 2005; Roy et al., 2009, 2011). Many studies have used the nociceptive flexion (RIII) reflex to analyse the effects of positive or negative emotions elicited, for example, by images, on descending modulation of the spinal transmission of nociceptive signals. The RIII reflex is not a measure of pain per se, but it is considered to be a reliable index of the spinal transmission of nociceptive signals because its threshold and amplitude are closely related to those of concomitant painful cutaneous sensations evoked by electrical stimulation (Sandrini et al., 2005). The amplitude of the nociceptive flexion (RIII) reflex typically increases if the subject is shown unpleasant pictures and decreases if the subject is shown pleasant pictures.

Using a similar experimental paradigm, we compared the RIII reflex modulation elicited by four standardized sets of pictures, including BDSM pictures and pictures with positive (erotic), negative (mutilations) or neutral emotional valences, between individuals regularly involved in predominantly masochistic BDSM activities and control subjects. Our working hypothesis was that descending modulation would be engaged differently in the MB subjects in the context of masochistic images, because they would be regarded as pleasant by these subjects (Rhudy et al., 2005, 2006, 2010).

We also systematically assessed the RIII reflex threshold and recruitment curves (up to the tolerance threshold), thermal (heat and cold) pain thresholds and responses to the pain sensitivity questionnaire before the subjects were shown the images, to compare basal pain sensitivity between our two groups of participants. We also used specific questionnaires to assess depression, anxiety, empathy, alexithymia, high sensation seeking and catastrophizing systematically in the subjects tested, to better characterize the psychological profiles of the participants and evaluate the potential influence of these factors on the emotional modulation of pain.

2 | MATERIALS AND METHODS

The study was approved by the local institutional review boards (CPP 8, Ile-de France-Ouest) and all participants provided written informed consent for inclusion in the study which was conducted from October 2018 to March 2021.

2.1 | Participants

The study sample consisted of two groups of paid male volunteers: 15 participants who routinely engaged in MB and 15 controls (i.e. participants not oriented towards masochism) matched for age and level of education (Table 1). The choice of including only men was motivated by the finding in some previous studies of differences in MB (Luo & Zhang, 2018; Wuyts et al., 2021) and in the effects of emotional (notably erotic and mutilation) images (Rhudy et al., 2010) between men and women, which might have significantly increased the variability of our results. The MB subjects were recruited from BDSM community clubs by advertisement and by requests made in person and the controls were recruited via advertisements. All the participants underwent a semi-structured interview concerning their sexuality with a psychologist (SB) during a screening visit to obtain information about their practice. All the selected MB participants reported a clear preference for the submissive role, including pain-related MB during active BDSM interactions. By contrast, the controls had never practiced BDSM-related activities. All the participants were heterosexual.

TABLE 1 Demographic and psychological characteristics of participants

	MB subjects ($n = 15$)	Controls ($n = 15$)	p
Age	46.53 (14.63)	46.20 (15.64)	0.952
Education (years)	15.73 (1.83)	16.33 (1.99)	0.397
Pain sensitivity questionnaire	55.20 (26.75)	63.80 (22.48)	0.349
State anxiety	40.93 (11.70)	35.15 (8.42)	0.130
Beck Depression Inventory	4.13 (3.98)	2.40 (1.99)	0.143
Pain Catastrophizing Scale	18.07 (8.06)	15.33 (7.08)	0.332
International Reactivity Index	61.07 (9.41)	57.20 (8.45)	0.246
Toronto Alexithymia Scale	50.46 (7.82)	46.06 (8.27)	0.209
High Sensation Seeking Scale	21.8 (7.23)	21.00 (5.46)	0.740

Note: Values are expressed as means (*SD*).

The exclusion criteria included diseases capable of causing neural damage (e.g. diabetes, alcoholism), the presence of skin lesions in the testing regions, a history of chronic pain and a current major depressive episode or chronic psychiatric disorder. “Switchers” (i.e. people who alternate between submissive and dominant roles) were excluded from the study. All participants were native French-speakers with a normal physical examination, no history of chronic pain (continuous or intermittent) and none were taking drugs affecting pain perception.

2.2 | General design of the study

After the screening visit, each volunteer participated in two experimental sessions separated by an interval of 2 ±1 weeks. During the first session, they responded to a series of questionnaires to assess anxiety, depression, catastrophizing, alexithymia, empathy, high sensation seeking and pain sensitivity. Quantitative sensory tests (QSTs) were then performed to assess the thermal detection and pain (heat and cold) thresholds of both hands (thenar eminence) and both feet (dorsum), with the various sites tested in a randomized order. During the second experimental session, we assessed the effects of four standardized sets of images with positive (erotic), negative (mutilations), masochistic or neutral valences on both the RIII nociceptive reflex and the intensity and unpleasantness of the pain elicited by electrical stimulation. The participants were then asked to assess the emotional value of each image.

2.3 | Questionnaires used in the study

A series of questionnaires were administered to the participants to better characterize their psychological profile including the Spielberger State–Trait Anxiety Inventory (Spielberger et al., 1983) to assess trait and state anxiety, the Beck Depression Inventory (Beck et al., 1961) to assess the presence and severity of depressive symptoms, the pain catastrophizing scale (Sullivan et al., 1995) to assess the thoughts and feelings of individuals concerning the experience of pain and the pain sensitivity questionnaire (Ruscheweyh et al., 2009) to assess general pain sensitivity.

We also administered the Toronto Alexithymia Scale (Bagby et al., 1994) to assess alexithymia, the International Reactivity Index (Davis, 1983) measuring the cognitive and emotional dimensions of the trait empathy, the Sensation Seeking Scale (Zucherman, 1979) measuring sensation seeking, defined as ‘the search for experiences and feelings that are varied, novel, complex and intense, and the prompt taking of physical, social, legal and financial risks’.

2.4 | Quantitative sensory testing

Thermal perception was evaluated with QSTs performed in a quiet room at constant temperature (22–23 °C). Subjects were seated in a comfortable reclining chair and asked to remain as relaxed as possible. We assessed the detection and pain thresholds for thermal sensations with a Somedic thermotest (Somedic AB, Stockholm, Sweden), as described previously (Attal et al., 2004; Bouhassira et al., 1999). A contact thermode of Peltier elements measuring 25 × 50 mm was applied to the skin over both thenar eminences and over the dorsum of both feet. The baseline temperature of the thermode was adjusted to the patient's skin temperature. Thresholds were measured by the method of limits (Frushstorfer et al., 1976): stimuli of increasing or decreasing intensities were applied and, for each stimulus, the subjects pressed a button that reversed the thermal stimulation as soon as they detected a sensation of cold or heat (for detection thresholds) or as soon as the stimulation became painful (for pain thresholds). The interstimulus intervals used were 6–8 s for detection thresholds, 15–20 s for heat pain thresholds (HPTs) and 20–30 s for cold pain thresholds. The maximum and minimum temperatures were set to 50°C for heat and 4°C for cold. The thermal rate of change was 1°C/s for detection thresholds and 2°C/s for pain thresholds. Thresholds were calculated as the mean threshold recorded in four successive detection tests and four successive pain tests and are expressed as absolute thresholds (°C).

2.5 | Nociceptive flexion RIII reflex recordings

The RIII reflex was evoked and recorded with a completely computerized system (Notocord Systems, Croissy, France), using previously described and validated techniques (Bossard et al., 2002; Bouhassira et al., 1998; Guirimand et al., 2000; Martin et al., 2007). In brief, the sural nerve was stimulated electrically with a pair of surface electrodes placed 2 cm apart on degreased skin overlying the nerve, along its retromalleolar path. Each electrical stimulus consisted of a train of five rectangular pulses, each lasting 1 ms, delivered over a 12 ms period by a constant current stimulator. Electromyographic responses were recorded from the ipsilateral biceps femoris muscle with a pair of surface electrodes placed 2 cm apart on the skin over the muscle. RIII reflex responses were identified as multiphasic waves appearing 90–180 ms after the onset of the stimulus. By restricting the study to responses within this timeframe, it is possible to avoid the tactile (RII) reflex, which can occur between 50 and 70 ms, or artefacts produced by involuntary movements, which can be observed 250–300 ms after the stimulus. Each reflex response was amplified, digitized, full-wave-rectified and integrated. The resulting integrals were used to quantify the RIII response. The experimental session began with construction of the recruitment curve for the reflex as a function of stimulus intensity, which was gradually increased to the tolerance threshold at a frequency of 0.17 Hz (i.e. 10 stimuli/min). The reflex threshold was defined as the intersection of the linear regression line for the RIII stimulus/response relationship with the abscissa. The tolerance threshold was the maximal intensity (mA) on the recruitment curve. The intensity of electrical stimulation of the sural nerve was then decrease to 20% above the RIII reflex threshold and kept constant during the four successive experimental sequences, each consisting of a 2-min control period, 1 min of image view and a 2-min post-image-viewing period. We also assessed the effects of each series of images on pain sensation, by asking the participants to rate the average pain intensity and unpleasantness induced by the electrical stimulation on two visual analog scales graduated as follows: "no pain–worst possible pain" and "not unpleasant–very unpleasant", at the end of the 2-min control period and just after the 1-min image-viewing period of each sequence.

2.6 | Images used as stimuli

Digital pictures with various emotional valence and arousal values were selected from the International Affective Picture System (Lang et al., 1999). These pictures have normative ratings for emotional valence and arousal and have been used in numerous previous studies (Rhudy et al., 2005, 2006, 2008). The images selected from the collection were split into three sets of 30 pictures with positive (erotic), negative (mutilations) or neutral emotional values. Another set of 30 masochistic images was selected from websites on the basis of ratings of emotional valence and arousal by masochistic subjects. All the images were presented on a computer screen placed on a table about 50 cm in front of the subjects during the four experimental sequences, each consisting of a 2-min control period, a 1-min image-viewing period and a 2-min post-viewing period. Each image was presented for 2 s, given a duration of 1 min for each image-viewing period. The order of presentation of the four sets of images was randomized.

After the electrophysiological session, the participants were asked to rate the emotional value of each of the 120 images. The Self-Assessment Manikin (SAM) was used to measure the affective valence (unpleasant-pleasant) and arousal (calm-excited) elicited by each image (Lang et al., 1999). We used a paper-and-pencil format of SAM consisting of two sets of five pictographs measuring affective valence (unpleasant–pleasant) and arousal (calm–excited). The participants responded by ticking on one of the five pictographs of each scale or between two of the pictographs. A rating between 1 and 9 was obtained for both affective valence and arousal (higher scores = greater pleasure or arousal).

2.7 | Data analysis

Results are expressed as the mean ± standard deviation. Due to the lack of previous studies using the same approach, the number of participants was calculated on the basis of previous studies in this fields (Defrin et al., 2015; Kamping et al., 2016; Pollok et al., 2010). For the comparison of recruitment curves between our two groups of participants, each reflex response was expressed as a percentage of the maximal response observed on the recruitment curve. Recruitment curves were normalized between 0 and 20 mA such that, if the tolerance threshold was <20 mA, the last value obtained for the reflex was assigned to all the higher intensities in the series (Bossard et al., 2002; Bouhassira et al., 1998; Guirimand et al., 2000). We analysed the effects of each sequence of images viewed on the reflex by averaging RIII responses over 1-min intervals and expressing the result as a percentage of the mean value during the 2-min control period. Analyses of variance (ANOVA) were performed, with Fisher's post hoc least significant difference tests for within- and between-group comparisons of demographic characteristics, reflex threshold, electrical stimulus tolerance thresholds, changes in RIII responses during each the viewing of each sequence of images, thermal thresholds and responses to clinical questionnaires. A p value <0.05 was considered significant.

3 | RESULTS

Fifteen subjects with MB and 15 controls completed the study. One MB subject and two controls who could not tolerate the electrical stimuli were not included in the RIII reflex analyses.

3.1 | Demographic and psychological characteristics

The two groups of participants were similar in terms of age and education level (Table 1). Scores for anxiety, depression, catastrophizing, empathy, alexithymia, sensation seeking and pain sensitivity were also similar between the two groups (Table 1).

3.2 | Basal pain sensitivity

The thermal pain thresholds measured on the right and left upper and lower limbs were similar and were averaged for group comparisons. As illustrated in Figure 1, there was no significant difference between the thermal detection and pain thresholds measured in the two groups.

RIII nociceptive reflex recruitment curves were similar in the two groups (Figure 2). The RIII reflex threshold was 8.7 ± 2.7 mA in MB subjects and 7.7 ± 3.0 mA in controls (p = 0.42). The tolerance threshold was 16.2 ± 4.6 mA in MB patients and 15.0 ± 4.2 mA in controls (p = 0.54).

3.3 | Effects of image-viewing on the RIII reflex and concomitant pain sensation

3.3.1 | Effects on the RIII reflex

Illustrative individual examples of the four set of images are presented in Figure 3 and the average effects in the two groups of participants are presented in Figure 4. Neutral, positive and negative images (Figure 4a–c) induced similar mean effects in the two groups, with a lack of significant effects of neutral images, a significant ($p < 0.001$) inhibition induced by the positive images and a significant ($p < 0.01$) facilitation induced by the negative images (not shown). By contrast, the masochistic images induced significantly different effects ($p < 0.001$) between groups, with a significant ($p < 0.01$) decrease in RIII reflex responses in MB subjects and a tendency (p = 0.06) towards an increase in these responses in control subjects (Figure 4d).

3.3.2 | Effects on the concomitant sensation of pain

Overall, the effects on the sensation of pain induced by electrical stimulation were consistent with those reported above for RIII reflex amplitude (Figure 5). The neutral images induced no change in pain intensity or unpleasantness. Positive images induced a similar decrease in both pain intensity and unpleasantness in the two groups. Negative images induced a similar increase in both pain intensity and unpleasantness in the two groups. By contrast, the effects of masochistic images were significantly different ($p < 0.01$) between the two groups, with a decrease in both the intensity (Figure 5a) and unpleasantness (Figure 5b) of pain in MB subjects, but not in controls.

3.3.3 | Image ratings

The emotional valence/pleasure and arousal ratings of the images are shown in Figure 6. The valence/pleasure ratings of neutral, positive (erotic) and negative (mutilations) images were similar in MB subjects and controls (Figure 6a). The valence/pleasure ratings of positive images were significantly higher than those of neutral images ($p < 0.01$), whereas the ratings of negative (mutilation) images were significantly lower than those of neutral images ($p < 0.01$) in both groups. By contrast, the valence/pleasure rating of masochistic images was significantly ($p < 0.001$) higher in MB subjects than in controls (Figure 6a).

Positive, negative and masochistic pictures were associated with significantly ($p < 0.01$) higher levels of arousal

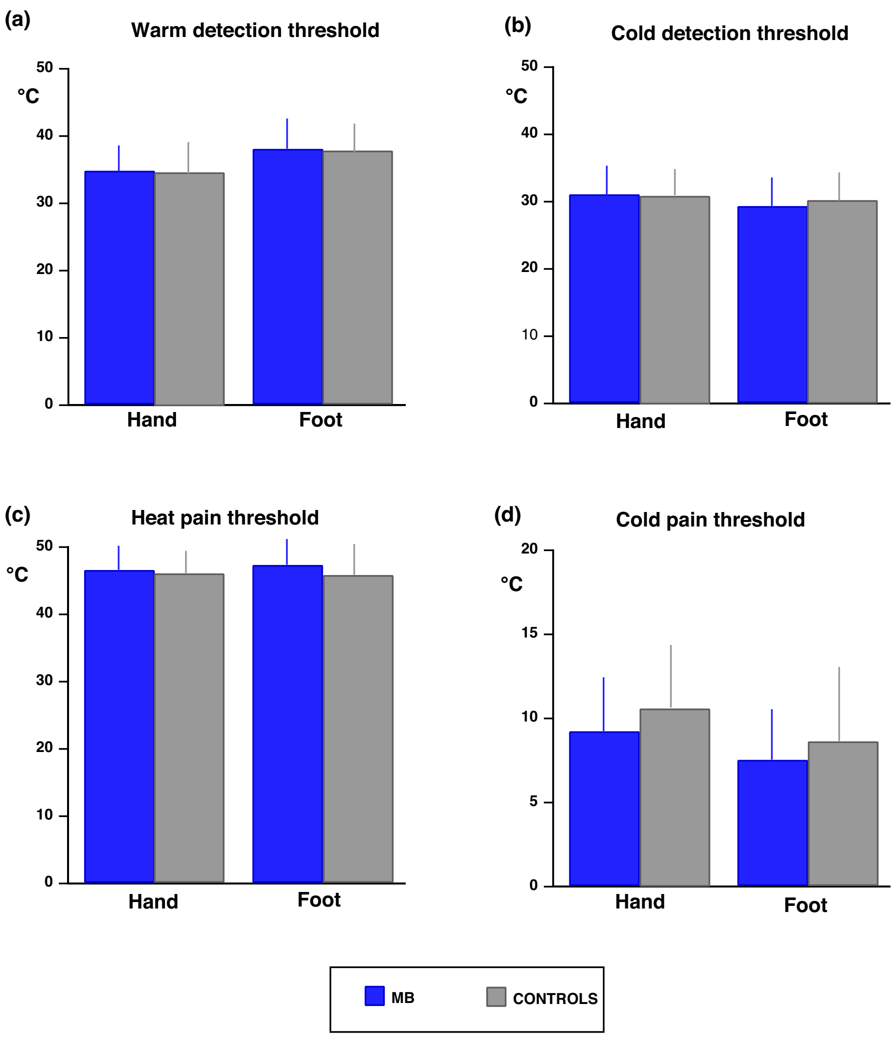

FIGURE 1 Comparisons of heat (a) and cold (b) detection thresholds, heat pain (c) and cold pain (d) thresholds (expressed in °C) measured on the lower (foot) and upper (hand) limbs in subjects with masochistic behaviour (MB) (blue columns) and controls (grey columns).

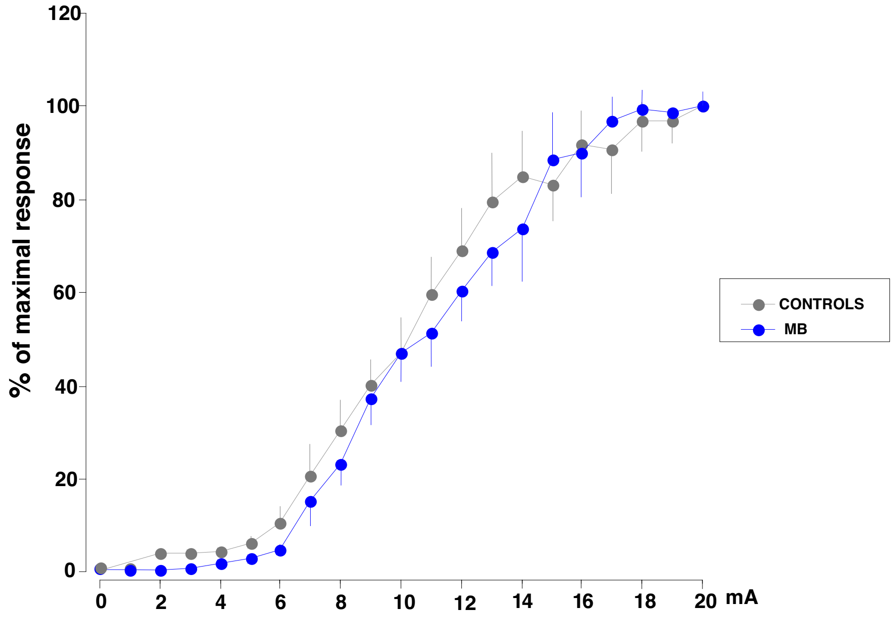

FIGURE 2 RIII reflex recruitment curves as a function of stimulus intensity, which was gradually increased to the tolerance threshold in subjects with masochistic behaviour (MB) (blue curve) and controls (grey curve). For the analysis of group data, each reflex response was expressed as a percentage of the maximal response observed on the recruitment curve.

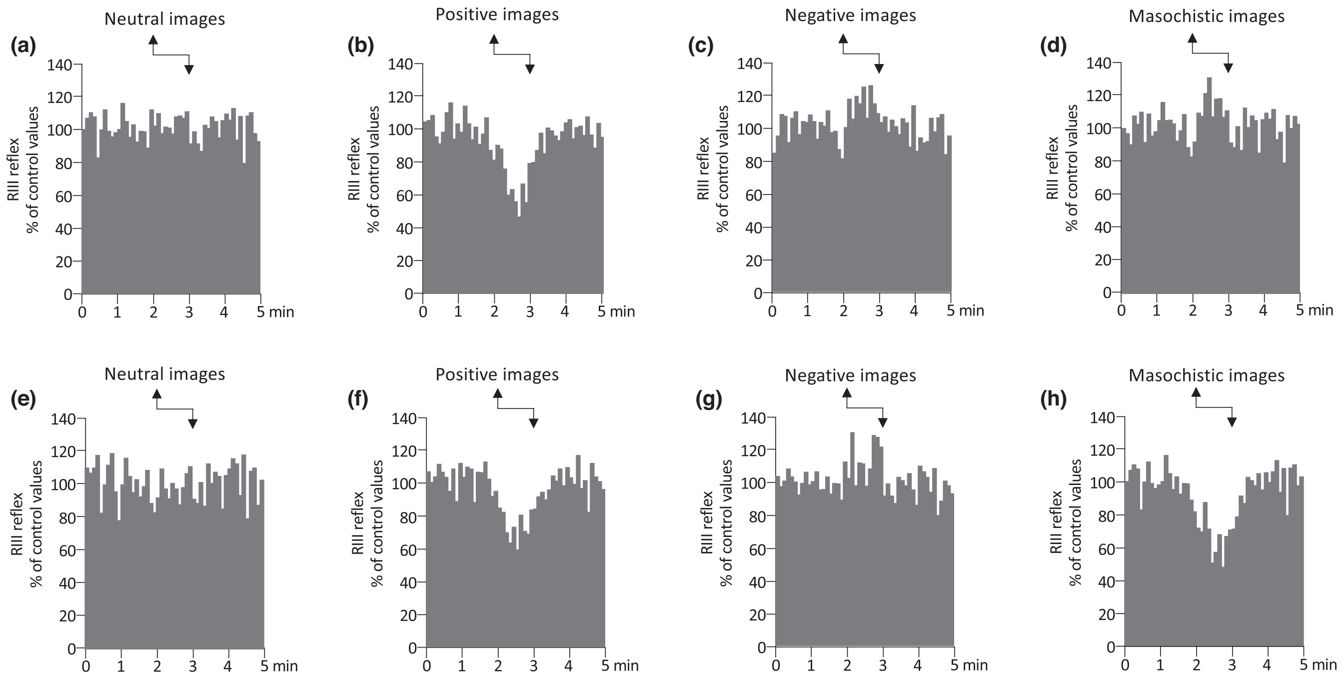

FIGURE 3 Illustrative individual examples of the effects of neutral, positive (erotic), negative (mutilations) and masochistic images on the RIII reflex in a control subject (a–d) and in a subject with masochistic behaviour (e–h). For each of the four successive 5-min experimental sequences (a–h), each bar of the histograms represents one single RIII reflex response expressed as a percentage of the mean value recorded during the 2-min control period (i.e. before image-viewing). The 1-minute image-viewing period (i.e. minute 3) is indicated by arrows.

than neutral images, but with no significant difference between controls and MB subjects (Figure 6b).

4 | DISCUSSION

Men with MB had similar basal pain sensitivity than controls, as indicated by QST, RIII nociceptive reflex characteristics and responses to the pain sensitivity questionnaire. The descending pain modulation elicited by emotional stimuli consisting of the viewing of positive, negative or neutral images was also similar between MB subjects and controls. Only the effects of masochistic images on descending pain modulation differed significantly between the two groups, suggesting selective activation of descending pain inhibition in subjects with MB.

Overall our results for basal sensitivity to pain obtained with experimental stimuli and the pain sensitivity questionnaire are consistent with the general notion that men with MB have normal pain perception in everyday life (Dunkley et al., 2020; Kamping et al., 2016), suggesting that these individuals have normal physiological nociceptive processes. In particular, the absence of change in RIII reflex recruitment curves, reflecting the spinal transmission of nociceptive signals, in our MB subjects provides an electrophysiological confirmation of the lack of major changes in spinal nociceptive transmission in these subjects. However, studies of the responses to experimental pain in masochists have reported conflicting results. Defrin et al. (2015) reported a significant increase in pressure pain threshold in a group of subjects with MB. Another study (Pollok et al., 2010) reported an increase in pain thresholds evoked by laser stimuli in a small group of subjects with MB ($n = 10$). Consistent with these results, a more recent study (Wuyts et al., 2021) reported an increase in the HPT, but not in the pressure pain threshold in subjects with MB. By contrast, Kamping et al. (2016) found no significant difference in the pain threshold evoked by laser stimuli between subjects with MB and controls, consistent with our finding of normal thermal (heat and cold) pain thresholds and electrical pain and tolerance thresholds in men with MB. These discrepancies are probably unrelated to the use of different modes of stimulation, because conflicting results have been reported for both mechanical and thermal stimuli. Similarly, differences in sex ratio cannot account for these differences, with only men included in our study, mostly female subjects in the study by Pollok et al. (2010) and mixed groups in the other studies. However, other differences regarding the experimental paradigms used in these studies (e.g. site of stimulation, psychological factors related to the subjects or to the experimental context) may also explained such discrepancies. One plausible explanation is that they reflect

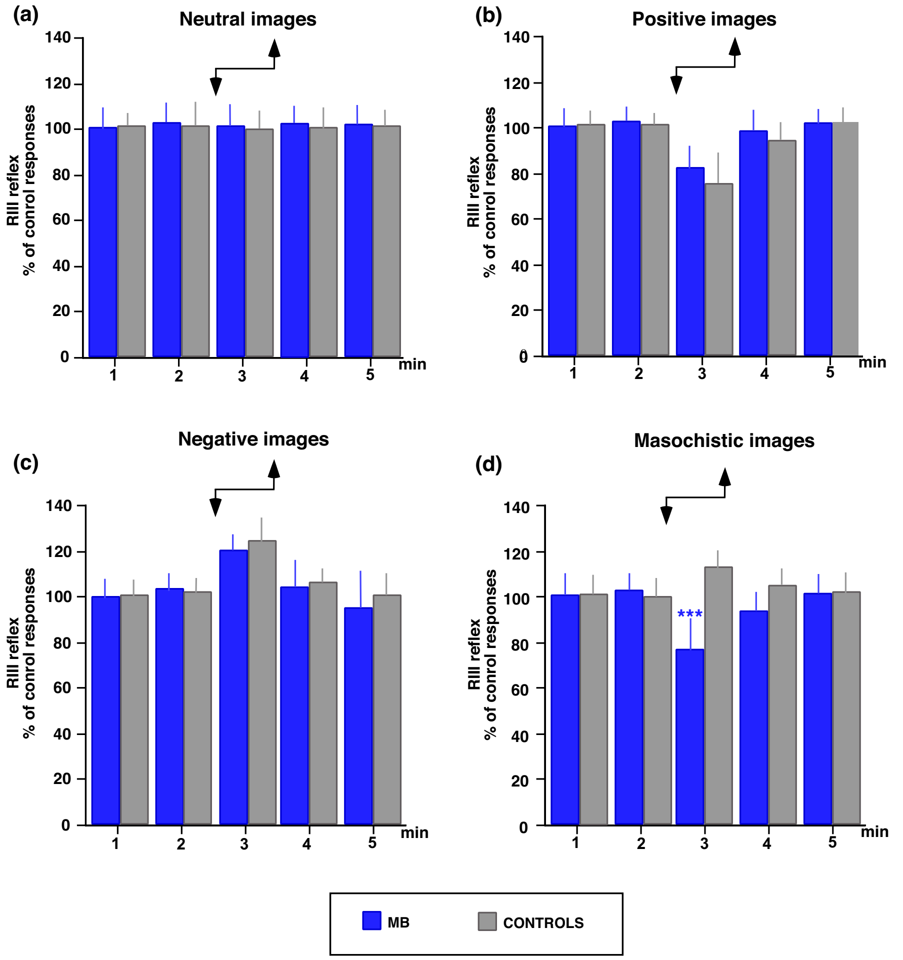

FIGURE 4 Mean effects of neutral images (a), positive images (erotic) images (b), negative (mutilations) images (c) and masochistic images (d) on the RIII reflex in subjects with masochistic behaviour (MB) (blue columns) and controls (grey columns). Mean RIII reflex responses during each of the 5 min of the four successive experimental sequences are expressed as a percentage of the mean value recorded during the 2-min control period. The 1-min image-viewing period (i.e. minute 3) is indicated by arrows. ***$p < 0.001$ for the comparison between subjects with MB and controls.

differences in the psychological profiles of the MB subjects included in the different studies. In both the study by Defrin et al. (2015) and that by Wuyts et al. (2021), changes in pain thresholds were associated with significantly lower catastrophizing scores in subjects with MB than in controls. By contrast, our subjects with MB had catastrophizing scores similar to those of controls. In any case, the lack of consistency of the results of these studies suggests that there are probably no major changes in physiological nociceptive processes specific to subjects with MB and that, even if such alterations exist, they probably concern only a subgroup of subjects. Interestingly, the similarity of other psychological characteristics, including anxiety, depression, empathy, alexithymia and high sensation seeking, between our subjects with MB and the controls also tends to confirm, consistently with previous studies (Brown et al., 2020), that there is no particular psychopathological profile associated with MB, although our results concerning a small group of participants should be interpreted with caution.

The main finding of our study was that descending modulation was differentially engaged during the viewing of masochistic images in subjects with MB. However, this differential activation of descending inhibition was not associated with a general alteration of the emotional modulation of pain in subjects with MB. Modulation of the RIII reflex and the concomitant sensation of pain elicited by positive (erotic), negative (mutilations) or neutral images were similar in controls and MB subjects. This finding is consistent with that of previous studies, which have repeatedly shown that emotionally evocative pictures can modulate pain (Rhudy et al., 2005, 2006, 2008). The findings for our participants confirm previous reports of an association of emotionally positive images with an inhibition of the RIII reflex, whereas negative images were associated with an enhancement of this reflex (Rhudy et al., 2005, 2006, 2008). In addition, modulation of the RIII reflex was associated with a concomitant modulation of the intensity and unpleasantness of pain induced by electrical stimuli (i.e. positive images were associated with decreases in both the intensity and unpleasantness of pain, whereas negative images increased both the intensity and unpleasantness of pain). These data suggest that the emotional descending modulation of pain is not altered in subjects with MB. The differences in the modulatory effects of masochistic images on the RIII reflex between subjects with MB and controls were, therefore,

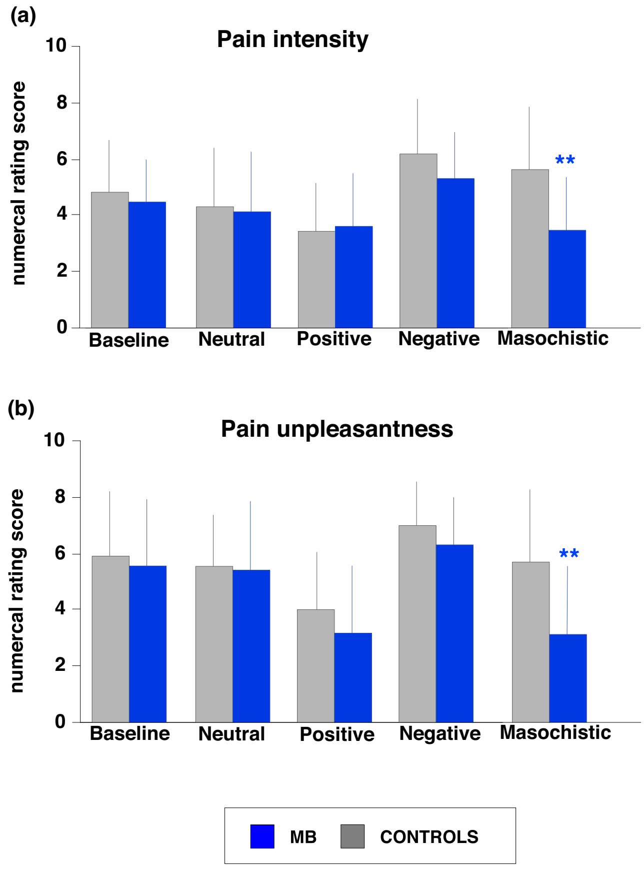

FIGURE 5 Effects of neutral, positive, negative and masochistic images (D) on the ratings (0–10 numerical rating scales) of the intensity (a) and unpleasantness (b) of the pain concomitantly elicited by electrical stimuli at the ankle during RIII reflex recordings in subjects with masochistic behaviour (MB) (blue columns) and controls (grey columns). $^{**}p < 0.01$ for the comparison between subjects with MB and controls

probably due to these images eliciting different valences/pleasure levels in the two groups. The valence/pleasure and arousal levels associated with these images were similar to those of positive images in subjects with MB, whereas they were closer to those of negative images in controls. Interestingly, as previously suggested (Rhudy et al., 2008, 2010), the emotional modulatory effects of image-viewing in our participants were related to the valence/pleasure associated with the images, but not with arousal levels. Positive and negative images elicited similar levels of arousal, but with opposite effects on the reflex and the concomitant sensation of pain.

Our results showing selective effects specific to the masochistic context are consistent with those of Kamping et al. (2016), who reported selective changes in brain activity associated with masochistic images in subjects with MB. The brain activation patterns associated with nociceptive stimuli in subjects with MB were similar to those of controls in non-masochistic contexts, whereas a dissociation of the activation of brain areas involved in the sensory-discriminative and affective pain dimensions was observed when nociceptive stimuli were associated with masochistic images. It has been suggested that the lower levels of activation in areas involved in affective-motivational aspects of pain, such as the anterior cingulate cortex and anterior insula, may be mediated by a differential activation of the operculum in the masochistic context. Our results are consistent with this hypothesis but suggest that complementary mechanisms relating to descending modulation of the spinal transmission of nociceptive signals are also specifically engaged in subjects with MB in masochistic contexts. The two types of mechanism are not

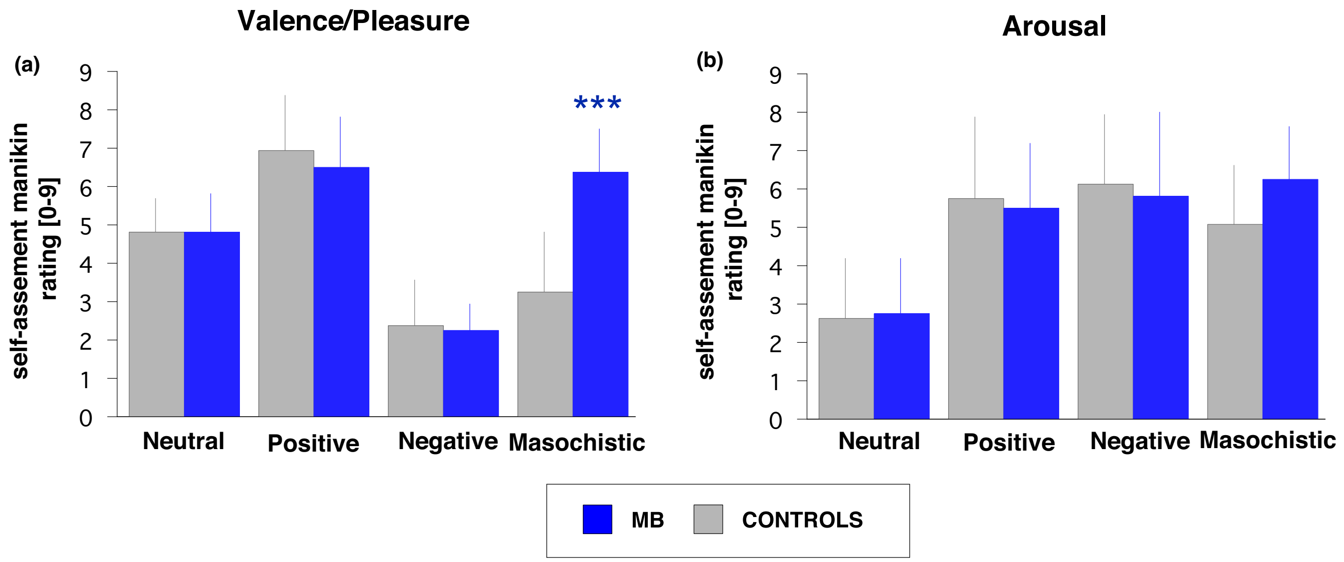

FIGURE 6 Self-Assessment Manikin ratings of valence/pleasure (a) and arousal (b) associated with emotionally neutral, positive, negative and masochistic images in subjects with masochistic behaviour (blue columns) and controls (grey columns). $^{***}p < 0.001$ for the comparison between subjects with MB and controls

mutually exclusive, and it would be interesting to combine the two experimental approaches (i.e. fMRI and RIII reflex recording) in future studies to investigate in more details whether brain and spinal mechanisms act simultaneously or correspond to different modulation "strategies" in different subjects. In any case, our results and those of Kamping et al. (2016) indicate that visual representation of the masochistic context is sufficient to decrease pain perception in MB subjects. Masochistic images may serve as a retrieval cue for mental representation in memory, which may, in turn, activate pain modulation. It is not possible to conclude from these studies based on experimental stimuli whether similar mechanisms operate during actual BDSM interactions, in which there are complex sexualized power exchanges between consensual partners in addition to painful stimuli. However, the results of two recent studies showing increases in experimental pain thresholds and blood endocannabinoid levels a few minutes after BDSM interactions (Wuyts et al., 2020, 2021) are consistent with a role for pain modulatory mechanisms during actual BDSM interactions.

One limitation of our study is the small number of participants. However, the effects reported here were generally large and the differences between our two groups of participants were clearly statistically significant. Another limitation is the inclusion of only male subjects in this study. Thus, although previous studies including mixed-sex populations of subjects with MB have found no major differences in pain perception between men and women with MB (Defrin et al., 2015; Kamping et al., 2016; Wuyts et al., 2020), we cannot generalize our results and it will be important to determine whether similar descending modulation-related mechanisms also operate in women with MB.

AUTHOR CONTRIBUTION

All authors contributed to the conception and design of the study and data acquisition. SB and DB analyse the data, SB draft the first version of the manuscript, which was commented and revised by the other authors.

ACKNOWLEDGEMENTS

This study was supported by Inserm. The authors would like to thank Dr Xavier Moisset for his technical assistance in the development of the experimental design.

FUNDING INFORMATION

This study was supported by Inserm.

CONFLICT OF INTEREST

The authors have no conflict of interest relating to this study to declare.

STATEMENT

Decreased pain perception associated with masochistic behaviours is related to a specific inhibition of the spinal transmission of nociceptive signals.

REFERENCES

Attal, N., Rouaud, J., Brasseur, L., Chauvin, M., & Bouhassira, D. (2004). Systemic lidocaine in pain due to peripheral nerve injury and predictors of response. *Neurology*, *62*(2), 218–225.

Bagby, R. M., Parker, J. D. A., & Taylor, G. J. (1994). The twenty-item Toronto Alexithymia scale-I. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research*, *38*(1), 23–32.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*, 561–571.

Bossard, A. E., Guirimand, F., Fletcher, D., Gaudé-Joindreau, V., Chauvin, M., & Bouhassira, D. (2002). Interaction of a combination of morphine and ketamine on the nociceptive flexion (RIII) reflex in human volunteers. *Pain*, *98*(1–2), 47–57.

Bouhassira, D., Attal, N., Willer, J. C., & Brasseur, L. (1999). Painful and painless peripheral sensory neuropathies due to HIV infection: A comparison using quantitative sensory evaluation. *Pain*, *1-2*, 265–272.

Bouhassira, D., Sabaté, J. M., Coffin, B., Le Bars, D., Willer, J. C., & Jian, R. (1998). Effects of rectal distensions on nociceptive flexion reflexes in humans. *The Journal of Physiology*, *275*(3), G410–G417.

Brown, A., Barker, E. D., & Rahman, Q. (2020). A systematic scoping review of the prevalence, etiological, psychological and interpersonal factors associated with BDSM. *Journal of Sex Research*, *57*(6), 781–811.

Davis, M. H. (1983). The effects of dispositional empathy on emotional reactions and helping: A multidimensional approach. *Journal of Personality*, *51*(2), 167–184.

De Neff, N., Coppens, V., Huys, W., & Morrens, M. (2019). Bondage-discipline, dominance-submission and sadomasochism (BDSM) from an integrative biopsychosocial perspective: A systematic review. *Sexual Medicine*, *7*(2), 129–144.

Defrin, R., Arad, M., Ben-Sasson, M. P., & Ginzburg, K. (2015). Attitudes and emotions towards pain and sensitivity to painful stimuli among people routinely engaging in masochistic behaviour. *European Journal of Pain*, *19*(9), 1321–1330.

Dunkley, C. R., Henshaw, C. D., Henshaw, S. K., & Brotto, L. A. (2020). Physical pain as pleasure: A theoretical perspective. *Journal of Sex Research*, *57*(4), 421–437.

Elsenbruch, S., Rosenberger, C., Bingel, U., Forsting, M., Schedlowski, M., & Gizewski, E. R. (2010). Patients with irritable bowel syndrome have altered emotional modulation of neural responses to visceral stimuli. *Gastroenterology*, *139*(4), 1310–1319.

Frushstorfer, H., Lindblom, U., & Schmidt, W. G. (1976). Method for quantitative estimation of thermal thresholds in patients. *Journal of Neurology, Neurosurgery, and Psychiatry*, *39*, 1071–1075.

Guirimand, F., Dupont, X., Brasseur, L., Chauvin, M., & Bouhassira, D. (2000). The effects of ketamine on the temporal summation (Wind-up) of the RIII nociceptive flexion reflex and pain in humans. *Anesthesia and Analgesia*, *90*, 404–414.

Kamping, S., Andoh, J., Bomba, I. C., Diers, M., Diesch, E., & Flor, H. (2016). Contextual modulation of pain in masochists: Involvement of the parietal operculum and insula. *Pain*, *157*(2), 445–455.

Lang, J. P., Bradley, M. M., & Cuthbert, B. N. (1999). *International affective picture system (IAPS): Instruction manual and affective ratings. Tech Rep A-4. The center for research in psychophysiology*. University of Florida.

Luo, S., & Zhang, X. (2018). Empathy in female submissive BDSM practitioners. *Neuropsychologia*, *116*(Pt A), 44–51.

Martin, F., Fletcher, D., Chauvin, M., & Bouhassira, D. (2007). Constitutive cyclooxygenase-2 is involved in central nociceptive processes in humans. *Anesthesiology*, *106*(5), 1013–1018.

Pollok, B., Krause, V., Legrain, V., Ploner, M., Freynhagen, R., Melchior, I., & Schnitzler, A. (2010). Differential effects of painful and non-painful stimulation on tactile processing in fibromyalgia syndrome and subjects with masochistic behavior. *PLoS One*, *5*(12), e15804.

Rhudy, J. L., Bartley, E. J., Williams, A. E., McCabe, K. M., Chandler, M. C., Russell, J. L., & Kerr, K. L. (2010). Are there sex differences in affective modulation of spinal nociception and pain? *Pain*, *11*(12), 1429–1441.

Rhudy, J. L., Williams, A. E., McCabe, K. M., Nguyen, M. A., & Rambo, P. L. (2005). Affective modulation of nociceptive at spinal and supraspinal levels. *Psychophysiology*, *42*(5), 579–587.

Rhudy, J. L., Williams, A. E., McCabe, K. M., Rambo, P. L., & Russell, J. L. (2006). Emotional modulation of spinal nociception and pain: The impact of predictable noxious stimulations. *Pain*, *126*(1–3), 221–233.

Rhudy, J. L., Williams, A. E., McCabe, K. M., Russell, J. L., & Maynard, L. J. (2008). Emotional control of nociceptive reactions (ECON): Do affective valence and arousal play a role? *Pain*, *136*(3), 250–261.

Roy, M., Lebuis, A., Peretz, I., & Rainville, P. (2011). The modulation of pain by attention and emotion: A dissociation of perceptual and spinal nociceptive processes. *European Journal of Pain*, *15*(6), 641.e1–641.e10.

Roy, M., Piché, M., Chen, J. I., Peretz, I., & Rainville, P. (2009). Cerebral and spinal modulation of pain by emotions. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(49), 20900–20905.

Ruscheweyh, R., Marziniak, M., Stumpenhorst, F., Reinholz, J., & Knecht, S. (2009). Pain sensitivity can be assessed by self-rating: Development and validation of the pain sensitivity questionnaire. *Pain*, *146*(1–2), 65–74.

Sandrini, G., Serrao, M., Rossi, P., Romaniello, A., Cruccu, G., & Willer, J. C. (2005). The lower limb flexion reflex in humans. *Progress in Neurobiology*, *77*(6), 353–395.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state-Trait Anxiety Inventory*. Consulting Psychologists Press.

Sullivan, M. L. J., Bishop, S. R., & Pivik, J. (1995). The pain catastrophizing scale: Development and validation. *Psychological Assessment*, *7*(4), 524–532.

Wuyts, E., De Neef, N., Coppens, V., Fransen, E., Schellens, E., Van Der Pol, M., & Morrens, M. (2020). Between pleasure and pain: A pilot study on the biological mechanisms associated with BDSM interactions in dominants and submissives. *The Journal of Sexual Medicine*, *17*(4), 784–792.

Wuyts, E., De Neef, N., Coppens, V., Schuerwegen, A., de Zeeuw-Jans, I., Van der Pol, M., & Morrens, M. J. (2021). Beyond pain: A study on the variance of pain thresholds within BDSM interactions in dominants and submissives. *The Journal of Sexual Medicine*, *18*(3), 556–564.

Zucherman, M. (1979). *Sensation seeking: Beyond the optimal level of arousal*. Erlbaum.

How to cite this article: Baudic, S., Poindessous-Jazat, F., & Bouhassira, D. (2022). Pain and masochistic behaviour: The role of descending modulation. *European Journal of Pain*, *26*(10), 2227–2237. https://doi.org/10.1002/ejp.2037