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From past pain to future pain through the pain of others: Information about other people's pain ratings can alleviate our subsequent pain

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Abstract

Background: Previous studies have shown that pain memories have a profound impact on subsequent pain experiences. This study investigated whether pain ratings derived from other people can modify an individual's memory of past pain. This study also examined whether pain memory modified by others' pain ratings determines subsequent pain experiences.

Methods: Participants were divided into two groups: an experimental group and a control group. Participants in both groups were exposed to pain stimulation; then, they recalled its intensity twice over a period of time; after a break, they were again exposed to pain stimulation of the same intensity. The final sample consisted of 53 participants. The only difference between the experimental group and the control group was that in the former the pain ratings of other alleged participants were presented between the two consecutive pain recalls. These ratings suggested that other people experienced the same pain as less intense.

Results: The pain ratings derived from other people did not alter the pain memory; nevertheless, they affected an individual's next pain experience even for a certain period of time after their presentation. This type of pain-related information shaped participants' subsequent pain experiences regardless of their empathy, conformity, and susceptibility to social influence.

Conclusions: Information on pain derived from other people not only shapes the response to a novel stimulation but also substantially modifies the subsequent experience of that stimulation.

Significance: The study demonstrates the importance of social information on pain and provides evidence that this type of information substantially modifies the subsequent experience of the same pain. These results suggest that social information on pain can be used to alleviate pain associated with recurring medical procedures and thus increase patients' willingness to continue treatment.

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1 | INTRODUCTION

Pain memories, like any other memories, become distorted (Adamczyk et al., 2019). However, the accuracy of pain memories seems critical for both diagnosis and therapy of pain. The diagnosis of patients' condition, the treatment choice and the assessment of its effects depend on how patients remember and describe their past pain experiences. Moreover, pain memories affect an individual's willingness to undergo future painful procedures and influence other treatment-related decisions (Kahneman et al., 1993; Redelmeier et al., 2003). Importantly, the memory of pain determines future pain experiences: previous studies show that current pain is more closely related to remembered pain than to experienced pain (Gedney & Logan, 2006; Noel et al., 2012).

Although pain memories have such important clinical implications, a relatively small number of studies have looked at changing them to be more positive. In most previous studies, children's pain memories were reframed by discussing participants' responses to painful procedures, for example, emphasizing their positive behaviours or adaptive coping strategies (Chen et al., 2000; Marche et al., 2016; Pickrell et al., 2007). In one previous study, adult participants were shown pain ratings that were allegedly theirs, but in fact they were lower than those they had given; in the majority of participants, this false feedback resulted in an underestimation of past pain (Urban et al., 2019).

Since showing pain is an effective, evolutionarily shaped tool for gaining social support in potential threat situations (Hadjistavropoulos et al., 2011), people are frequently exposed to others' verbal and non-verbal pain manifestations. Previous studies have shown that knowledge of how other people rated pain intensity influences an individual's pain experience when subjected to the same pain stimulation (Koban & Wager, 2016; Koban et al., 2019; Yoshida et al., 2013). When participants were presented with pain ratings derived from other people indicating that pain was of low intensity, this resulted in them experiencing less intense pain sensations. Importantly, social information on pain turned out to be more potent than learned cues in shaping pain-related expectancies and thus responses to pain, even when the learned cues allowed better pain prediction (Koban & Wager, 2016). The current study aimed to explore whether social information on pain can modify the way the pain is recalled and experienced after a period of time.

There is evidence that memory is susceptible to change each time it is retrieved (Alberini & Ledoux, 2013). New information related to existing memories may be incorporated into memory during this process, leading to the biased reconstruction of past information. Considering the plasticity of memory and the importance of the social environment as a source of information on pain, we hypothesized that providing participants with other people's pain ratings showing that they had felt less pain would make participants' pain memories more positive (H1); pain memory modified in this way would make subsequent pain experiences less intense (H2). Participants' empathy and tendencies to conform to others and yield to social influence were controlled for to explore whether they were related to susceptibility to the social information used in the study.

2 | MATERIALS AND METHODS

2.1 | Sample size

The sample size was determined based on the within-between interaction effect size ($f = 0.20$) derived from a previous study (Bajcar et al., 2022) that investigated the effect of other people's pain ratings on the induction of placebo hypoalgesia. To detect a significant difference in pain intensity between the groups, it was estimated that a minimum sample of 18 participants was required per group ($\alpha = 0.05$, 80%, corr = 0.5, within-between interaction). However, to account for potential dropouts, a threshold of 30 participants was set for each group. The calculation was performed using G*Power 3.1.9.2 software (Faul et al., 2007).

2.2 | Participants

A total of 77 volunteers took part in the study. We stopped collecting data when we had tested 60 participants who gave a first pain intensity rating of 30 or more on the Visual Analogue Scale (VAS) with a length of 100 mm. During the experiment, participants were presented with a pain intensity rating and were told that this was the average from ratings provided by other people allegedly subjected to the same painful stimulation. The presented rating was always lower by 25 points on the VAS than the rating provided by the participant during the first pain stimulation. This interval of 25 points was chosen to ensure that the difference between the participant's rating and the presented rating would be noticeable. Therefore, those who rated the intensity of pain lower than 30 points on the VAS had to be excluded from the study because in these cases the intended presentation of a pain rating from other people was not possible. Thus, 60 participants, including 34 females (56%), were the relevant sample. However, before the data analysis, the data from another seven participants were excluded as they figured out the

actual aim of the experiment. Therefore, the final sample consisted of 53 participants. Participants were recruited by postings on social media and classified advertisement websites. All participants underwent the screening phase by means of an internet survey in order to qualify only mentally and physically healthy people that had no prior experience with experimentally induced pain and were not using alcohol, narcotics, painkillers or stimulants around the time of the study. The use of these substances might have reduced the possibility of experiencing experimental pain. Data also shows that depression and negative emotions can lower pain thresholds and affect pain responses (Carter et al., 2002; Hermesdorf et al., 2016). Therefore, the Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983) was included in the survey to exclude individuals with symptoms of anxiety or depression. All the characteristics of the participants from the final sample are presented in Table 1.

The participants were randomly allocated to (1) the experimental ($N = 23$) or (2) the control group ($N = 30$). They were informed that they would take part in a study on the perception of thermal pain and would receive painful thermal stimulation; they were told that they could withdraw their consent to participate at any time during the experiment without providing a reason. For their participation in the study, they were compensated financially at the end of the experiment. The study protocol was accepted by the Research Ethics Committee at the Institute of Psychology, Jagiellonian University, Kraków, Poland (decision number KE/02/06/2017).

2.3 | Stimuli

2.3.1 | Pain stimuli

Two thermal pain stimuli were applied, each of which lasted 60 s. The stimulus temperature rose from the baseline temperature (32°C) to the target temperature of 45.5°C with a 10°C/s ramp-up/ramp-down ratio and 60 s plateau. The temperature of the stimuli was set at 45.5°C for all participants. This temperature was established in a pilot study that examined 29 participants. The pilot study aimed to find a temperature that would elicit a sensation considered painful by most participants yet would not cause too much discomfort. We achieved this goal as the average pain intensity rating provided by the participants in the pilot study was 41 on VAS. What is more, in the presented study, pain intensity ratings of the first pain stimulation ranged from 31 to 85 on the VAS with seven people reporting severe pain (>70; Kelly, 2001). For the second pain stimulation, intensity ratings varied from 7 to 91 on the VAS with seven participants reporting severe

TABLE 1 Characteristics of participants in each group and in total (means and standard deviations)

					FPQ				HADS	
Group	Gender	Age (yo)	Height (cm)	Weight (kg)	General	FSP	FMP	FM/DP	A	D
Experimental (N = 23)	12F (52%) 11 M (48%)	24.22 ± 4.63	173.70 ± 10.20	68.13 ± 12.99	71.43 ± 18.61	28.48 ± 7.86	18.44 ± 6.63	24.52 ± 8.37	3.17 ± 1.78	1.87 ± 2.07
Control ($N = 30$)	17F (57%) 13 M (43%)	22.90 ± 3.75	173.27 ± 10.93	69.50 ± 13.87	73.13 ± 18.25	31.00 ± 8.03	18.60 ± 6.20	23.53 ± 7.53	3.47 ± 2.05	2.03 ± 2.09
All (N = 53)	29F (55%) 24 M (45%)	23.47 ± 4.17	173.45 ± 10.52	68.91 ± 13.38	72.40 ± 18.25	29.91 ± 7.98	23.96 ± 7.84	23.96 ± 7.84	3.34 ± 1.92	1.96 ± 2.07
Intergroup differences (statistics and p-values)	$X^2(1, N = 53) = 0.11$ $p = 0.745$	$F(1, 51) = 1.31$ $p = 0.258$	$F(1, 51) = 0.02$ $p = 0.885$	$F(1, 51) = 0.13$ $p = 0.716$	$F(1, 51) = 0.11$ $p = 0.741$	$F(1, 51) = 1.31$ $p = 0.258$	$F(1, 51) = 1.01$ $p = 0.926$	$F(1, 51) = 0.20$ $p = 0.654$	$F(1, 51) = 0.30$ $p = 0.587$	$F(1, 51) = 0.08$ $p = 0.778$

Abbreviations: A, Anxiety Scale; D, Depression Scale; FPQ, Fear of Pain Questionnaire; FSP, Fear of Severe Pain; FMP, Fear of Minor Pain; FM/DP, Fear of Medical/Dental pain; HADS, The Hospital Anxiety and Depression Scale.

pain. In total, 11 participants reported severe pain during at least one of the two pain stimuli applications. Stimuli were delivered to the volar surface of the non-dominant forearm using a thermode of the Pathway Pain & Sensory Evaluation System (model ATS, Medoc, Israel).

2.3.2 | Pain-related information

Participants from the experimental group were presented during the *pain memory modification phase* with the information about pain ratings allegedly derived from other people who experienced the same thermal stimulation. On a black screen, the pain rating delivered by the participant was shown as a red vertical bar on the VAS. After a few seconds, the alleged average pain rating of other participants (the exact number of participants was not stated) that had previously taken part in the experiment was presented as a yellow vertical bar on the same scale. In fact, it was always 25 points lower than the participant's rating.

2.4 | Measures

2.4.1 | Pain intensity

Pain intensity was rated on the VAS with a length of 100 mm, ranging from 'no pain' at the left-hand end to 'the most intense pain tolerable' at the right-hand end.

2.4.2 | Psychological traits

Three questionnaires were applied in order to determine if there was a relationship between compliance, susceptibility to social influence, empathy, and the influence of pain-related information on the memory of pain. *The Gudjonsson Compliance Scale* (GCS) (Gudjonsson, 1989) is a self-report questionnaire that measures compliance (the tendency to conform to requests made by others). The GCS consists of 20 statements that can be responded to as "True" or "False"; the global score is calculated as the number of affirmative responses. The *Measure of Susceptibility to Social Influence* (MSSI) (Bobier, 2002) was designed to assess the possible responses to social influence, which are pressure-independence (Principled autonomy), conformity/compliance (Social adaptability) and anticonformity (Social friction). The MSSI consists of 34 items, rated on a 5-point Likert scale; the global score is calculated as the sum of all subscales. The *Interpersonal Reactivity Index* (IRI) (Davis, 1980) was used to measure trait empathy. The Polish version of this questionnaire (Kaźmierczak et al., 2007) contains 21 items divided into three subscales: Empathic concern, Perspective-taking and Personal distress, all of which were rated on a 5-point Likert scale. In order to control for differences in the fear of pain between groups, the *Fear of Pain Questionnaire-III* (FPQ-III) (McNeil & Rainwater, 1998) was applied. FPQ-III is a 30-item scale that measures the fear of pain divided into three subscales: Severe Pain, Minor Pain, and Medical Pain, all of which were rated on a 5-point Likert scale.

2.4.3 | Manipulation check questions

At the end of the study, participants were also asked what in their opinion the aim of the experiment had been; how much others' ratings had affected their memory of pain and their experience of pain; and how hard they had tried to adjust their pain ratings to the ratings of other people.

2.4.4 | Filler task

During the first break (between the first pain stimulation and the first pain recall phases), as a filler task participants completed three questionnaires that were irrelevant to the purpose of the study: (1) *Vividness of Visual Imagery Questionnaire* (VVIQ) (Marks, 1973); (2) *Positive and Negative Affect Schedule* (PANAS) (Watson et al., 1988); (3) *Ten Item Personality Inventory* (TIPI-PL) (Sorokowska et al., 2014).

2.5 | Procedure

Both groups underwent the *first pain stimulation*, the *first pain recall*, the *second pain recall* and the *second pain stimulation* phases. The experimental group additionally went through the *pain memory modification* phase, while the control group did not. The whole experiment lasted approximately 1 h and 15 min; however, participants spent 30 min of this time in the waiting room and not in the laboratory. The experimental design is presented in Figure 1.

2.5.1 | The first pain stimulation

Participants received one thermal pain stimulus lasting 60 s. Immediately after the end of its application, they rated the intensity of the experienced pain on the VAS. Afterwards, participants were asked to complete some questionnaires as a filler task during the 10-min break between the first pain stimulation and the first pain recall.

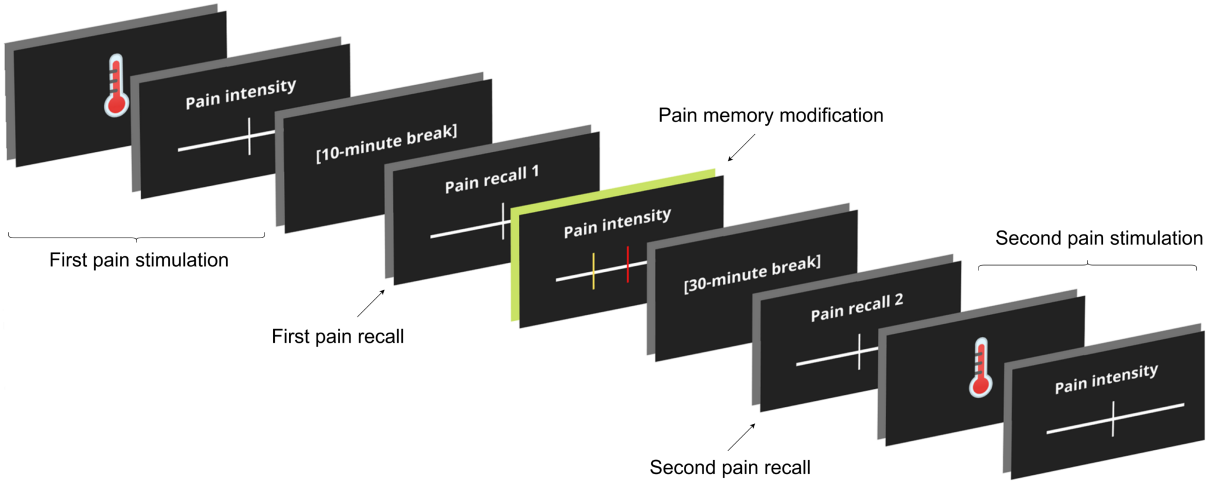

FIGURE 1 Study design: Participants in both groups underwent the first thermal pain stimulation, the first pain recall, the second pain recall and the second thermal pain stimulation. Additionally, between the first and the second pain recall, participants in the experimental group underwent the pain memory modification phase (shown on a green background), during which pain ratings provided by the alleged group of previous participants were presented (as a yellow vertical bar) on the VAS next to participant's rating (as a red vertical bar).

2.5.2 | The first pain recall

After the break, participants were asked to recall the pain they had experienced during the first pain stimulation and to rate its intensity on the VAS (as they then remembered it).

2.5.3 | Pain memory modification

Participants from the experimental group were told that during the 10-min break a computer program had selected from a database pain ratings given by people similar to them in terms of gender, age and the results obtained in the preliminary survey (on the basis of which they qualified for the study). The participants were informed that we compared how they and people similar to them rated a stimulus of the same intensity (which meant the same temperature). Then, the pain ratings provided by the alleged group of previous participants were presented on the screen. The VAS was shown with the participant's rating marked in red colour (with the description "the red bar presents your rating"); a few seconds later, the average rating given by the alleged previous participants in this experiment was presented as a yellow bar next to it (with the description "the yellow bar presents ratings provided by others"). However, the rating that was allegedly calculated from the ratings of other participants was placed 25 points lower on the VAS so the participant's rating was always higher than others' average rating (see Figure 1). Subsequently, participants were informed that there would be a 30-min break which they would take outside of the laboratory. They waited in the waiting room next to the laboratory and were asked not to smoke cigarettes or consume any caffeinated products. The control group was designed to control for naturally occurring distortions in pain memory. Therefore, neither information about participant's pain rating nor information about other people's pain ratings was presented in this group.

2.5.4 | The second pain recall

After the break, participants were asked to recall again the pain they experienced during the stimulus application and to rate its intensity on the VAS.

2.5.5 | The second pain stimulation

Participants again received the thermal stimulus of the same duration and intensity as in the first pain stimulation. Immediately after the end of its application, they rated the intensity of pain on the VAS. In the course of the experiment, participants were not informed that the pain stimulus would be reapplied. They were also not informed that the second stimulus would be of the same intensity as the previous one.

Then, participants in both groups were asked what in their opinion the goal of the study was. In addition, participants in the experimental group answered a series of manipulation check questions.

2.6 | Statistical analyses

Participants were excluded from analyses for the following reasons: if any error occurred during the procedure,

if they terminated the experiment prematurely, if they realized what the real aim of the study was or if they rated pain intensity less than 30 on the VAS during the first pain stimulation. However, they were compared with the final sample by means of a one-way ANOVA to check whether these groups differed in terms of basic characteristics.

Descriptive statistics (means and SDs) were calculated for the following variables: age, height, body mass, fear of pain measured by FPQ-III, anxiety and depression measured by HADS. To investigate whether the experimental and control groups differed in these variables, a one-way ANOVA design with "group" (experimental and control) as a between-subject factor was performed. Moreover, a chi-squared test was performed to check whether the gender distribution was similar in both groups.

In the main analysis, a repeated-measures ANOVA followed by the planned comparison tests was performed on participants' VAS ratings. The "group" (experimental and control) was a between-subject factor, while "rating" (the first pain stimulation, the first pain recall, the second pain recall, the second pain stimulation) was a within-subject factor. Planned comparison tests were performed to compare the following differences in the experimental group with the same differences in the control group: between the VAS ratings from the first pain stimulation and the second pain stimulation; between the first pain stimulation and the first pain recall; between the first pain recall and the second pain recall; and between the second pain recall and the second pain stimulation.

To verify whether the first pain experience or pain memory affected the second pain experience and whether their impact differed between the groups, a hierarchical regression analysis was performed. In the analysis, the second pain experience was predicted from the main effects of group, the first pain stimulation, the first pain recall, the second pain recall (entered in Step 1), and the interaction effects of the first pain stimulation × group, the first pain recall x group, the second pain recall x group (entered in Step 2). The "group" variable was dummy coded (experimental = 1, control = 0).

Additionally, Pearson correlation coefficients (r) were calculated in the experimental group to explore the relationships between the differences in the VAS ratings in the first pain stimulation and in the second pain stimulation; between the first pain recall and the second pain recall; and between any of the questionnaires' scores (GCS, MSSI, IRI) and the answers to the manipulation check questions.

The alpha level was set at 0.05 for rejection of the null hypothesis in all statistical analyses. Bonferroni correction was used in the correlational analyses to control for multiple comparisons. All the analyses were conducted using STATISTICA data analysis software, version 13 (StatSoft Inc.).

3 | RESULTS

Throughout the data collection, the data from 24 participants were excluded from the data analyses (see Participants section). The one-way ANOVA confirmed that the excluded persons did not differ from the analysed sample in terms of basic characteristics. The final sample for the analyses consisted of data obtained from 53 participants (23 in the experimental group and 30 in the control group). The one-way ANOVA revealed that there were no significant differences between groups (experimental and control) in gender, age, height, body mass, fear of pain, anxiety and depression (participants' characteristics are presented in Table 1).

3.1 | Main analysis

The repeated measures ANOVA on the VAS ratings revealed a statistically significant main effect of "rating" ($F_{(3,\ 153)} = 30.41$, $p < 0.001$, $\eta^2_p = 0.37$) and a statistically significant "rating" × "group" interaction ($F_{(3,\ 153)} = 4.70$, $p < 0.004$, $\eta^2_p = 0.08$). No significant main effect of "group" ($F_{(1,\ 51)} = 0.20$, $p = 0.653$, $\eta^2_p < 0.01$) was found.

The between-group planned comparison showed that the difference between the first pain stimulation and the second pain stimulation in the experimental group was significantly higher than the same difference in the control group ($F_{(1,\ 51)} = 4.47$, $p = 0.011$, $\eta^2_p = 0.08$). The means indicate that the second pain rating was lower than the first pain rating in the experimental group, while remained at similar level in the control group (Table 2). This result confirms the influence of the pain ratings presentation on participants' second pain stimulation. The difference between the second pain recall and the second pain stimulation appeared to be significantly higher in the control group than in the experimental group ($F_{(1,\ 51)} = 6.98$, $p = 0.039$, $\eta^2_p = 0.12$). The means indicate, that in both groups, the second pain stimulation was rated higher than the second pain recall, however, the change was more considerable in the control group. Furthermore, the groups did not differ significantly in the magnitude of the difference between the first pain stimulation and the first pain recall ($F_{(1,\ 51)} = 2.49$, $p = 0.121$, $\eta^2_p = 0.05$) and between the first pain recall and the second pain recall ($F_{(1,\ 51)} = 0.76$, $p = 0.387$, $\eta^2_p = 0.01$) (Figure 2). These results indicate that pain memories were not modulated by the presentation of other people's pain ratings (H1), therefore the change in pain sensation throughout the experiment could not

TABLE 2 Descriptive statistics for first pain stimulation, first pain recall, second pain recall, second pain stimulation VAS ratings and questionnaires' scores in each group and in total (means and standard deviations)

Gr.	IRI				MSSI			VAS ratings			
	PT	PD	EC	GCS	PA	SA	SF	First stimulation	First recall	Second recall	Second stimulation
Experimental ($N = 23$)	35.26 ± 4.10	22.00 ± 7.08	40.22 ± 6.04	8.00 ± 3.50	55.87 ± 8.08	31.26 ± 8.09	25.43 ± 4.84	51.61 ± 15.69	45.00 ± 20.55	32.52 ± 23.59	39.74 ± 21.55
Control ($N = 30$)	33.43 ± 3.80	22.77 ± 3.87	39.57 ± 6.24	8.90 ± 3.80	54.67 ± 7.71	33.33 ± 6.80	25.07 ± 4.87	50.00 ± 15.51	36.53 ± 16.54	27.40 ± 17.44	47.03 ± 18.06
All (53)	34.23 ± 4.00	22.43 ± 5.45	39.85 ± 6.10	8.51 ± 3.67	55.19 ± 7.82	32.43 ± 7.39	25.23 ± 4.81	50.70 ± 15.46	40.21 ± 18.69	29.62 ± 20.29	43.87 ± 19.79
Intergroup differences (statistics and p = values)	$F(1, 51) = 2.81$ $p = 0.010$	$F(1, 51) = 0.25$ $p = 0.616$	$F(1, 51) = 0.15$ $p = 0.704$	$F(1, 51) = 0.78$ $p = 0.381$	$F(1, 51) = 0.30$ $p = 0.584$	$F(1, 51) = 1.03$ $p = 0.316$	$F(1, 51) = 0.08$ $p = 0.786$	$F(1, 51) = 0.14$ $p = 0.711$	$F(1, 51) = 2.76$ $p = 0.103$	$F(1, 51) = 0.83$ $p = 0.368$	$F(1, 51) = 1.80$ $p = 0.186$

Abbreviations: EC, empathic concern; GCS, Gudjonsson Compliance Scale; IRI, interpersonal reactivity index; MSSI, measure of susceptibility to social influence; PA, principled autonomy; PD, personal distress; PT, perspective taking; SA, social adaptability; SF, social friction; VAS, visual analogue scale.

FIGURE 2 Between-group planned comparisons of mean pain and pain memory VAS ratings. The difference between the first pain stimulation and the second pain stimulation in the experimental group was significantly higher than the same difference in the control group. The difference between the second pain recall and the second pain stimulation was significantly higher in the control group than in the experimental group. *$p \leq 0.05$, **$p \leq 0.01$.

be caused by altered memory of pain (H2). Hence, both of our hypotheses were not confirmed. Table 2 presents the means and standard deviations for the first pain stimulation, the first pain recall, the second pain recall, the second pain stimulation VAS ratings, and questionnaires' scores. Figure S1 presents the distribution of VAS ratings in the experimental and control groups for the first pain stimulation, first pain recall, second pain recall, and second pain stimulation.

3.2 | Regression analysis and correlations

The first step of the hierarchical regression analysis confirmed that the second pain stimulation differed between the groups ($\beta = -0.28$, $p = 0.008$), indicating that participants from the experimental group experienced lower pain relative to the control group. Moreover, the first pain stimulation predicted the second pain stimulation ($\beta = 0.38$, $p = 0.004$) above and beyond the other predictors. Similarly, the association between the second pain recall and the second pain stimulation was close to reaching a significance level ($\beta = 0.30$, $p = 0.055$), while controlling for the other predictors. The second step of the

TABLE 3 Results of the hierarchical regression analysis, in which second pain experience was predicted from the main effects of group, first pain stimulation, first pain recall, second pain recall (entered in Step 1), and the interaction effects of first pain stimulation x group, first pain recall x group and second pain recall x group (entered in Step 2)

	β	t	p	R^2	Adj. R^2	F	p
Step 1							
Group	−0.28	−2.75	0.008	0.55	0.51	14.62	<0.001
First pain	0.38	3.06	0.004				
First recall	0.15	0.94	0.353				
Second recall	0.3	1.97	0.055				
Step 2							
Group	−0.25	−0.65	0.517	0.55	0.48	7.84	<0.001
First pain	0.38	2.01	0.051				
First recall	0.14	0.52	0.604				
Second recall	0.33	1.4	0.17				
Group × First pain	−0.02	−0.03	0.973				
Group × First recall	0.02	0.04	0.968				
Group × Second recall	−0.04	−0.12	0.903				

TABLE 4 Results of correlational analysis of the changes in VAS ratings due to experimental manipulation and either questionnaires' scores or answers to manipulation check questions (Pearson's r)

	IRI				MSSI					
	PT	PD	EC	GCS	PA	SA	SF	MCQ1	MCQ2	MCQ3
Change in pain sensation ratings (first pain stimulation and second pain stimulation difference)	0.21	0.28	0.06	0.39	0.21	0.44	0.03	0.04	−0.05	−0.10
Change in pain memory ratings (pain first pain recall and second pain recall difference)	−0.27	−0.23	−0.26	0.14	−0.04	0.25	0.02	−0.28	−0.17	−0.12

Note: After Bonferroni correction, none of the correlation coefficients reached the required significance threshold.

MCQ1 = How much did the other persons' pain ratings affect the way you remembered the pain?

MCQ2 = How much did the other persons' pain ratings affect your pain sensation?

MCQ3 = How much did you try to adjust your pain intensity ratings to the other persons' ratings?

Abbreviations: EC, empathic concern; GCS, Gudjonsson compliance scale; IRI, interpersonal reactivity index; MCQ, Manipulation check question; MSSI, measure of susceptibility to social influence; PA, principled autonomy; PD, personal distress; PT, perspective taking; SA, social adaptability; SF, social friction, VAS, visual analogue scale.

model showed that all interaction effects included in the model were insignificant, indicating that the relationship between the first pain stimulation, the first pain recall, the second pain recall and the second pain stimulation was not moderated by the group. Moreover, the results showed an increase in $R^2 = 0.00$ ($p = 0.999$) after including the interaction to the model. The full results of the regression analysis are presented in Table 3.

Correlational analysis revealed that the differences in VAS ratings between the first pain stimulation and the second pain stimulation as well as between the first pain recall and the second pain recall did not correlate with the GCS, MSSI and IRI scores (each of their subscales separately). These results indicate that participants' levels of empathy, compliance, and susceptibility to social influence were not associated with either the change in pain or the pain memory ratings induced by pain-related information derived from others. Similarly, the differences in VAS ratings between the first pain stimulation and the second pain stimulation and between the first pain recall and second pain recall did not correlate with the answers to the manipulation check questions (obtained correlation coefficients are presented in Table 4).

4 | DISCUSSION

The most important finding from this study is that the experience of pain may be altered by pain ratings derived from other people. Moreover, others' pain ratings have

been shown to affect an individual's pain experience even for a certain period since their presentation. This type of pain-related information affected participants' subsequent pain experiences regardless of their empathy, conformity and susceptibility to social influence; however, it did not influence their pain memory.

In previous studies, the memory of pain was modified mainly by exposing participants to misleading information regarding their past pain-related behaviours (Chen et al., 2000; Marche et al., 2016; Pickrell et al., 2007; Urban et al., 2019). However, people are susceptible to pain signals provided by others: observing another person's responses to pain can shape the observer's pain sensations (Goubert et al., 2011). Previous studies proved that in the presence of a person who demonstrated tolerance to pain, people experiencing pain reported less pain, experienced reduced physiological arousal (Craig & Prkachin, 1978), and displayed less pronounced non-verbal pain behaviours (Prkachin & Craig, 1985). Thus, observing another person experiencing pain affected different pain-related responses in the observer. Recent studies have shown that individual perception of pain can be influenced merely by showing how other people previously subjected to the same painful stimulation have rated its intensity (Koban & Wager, 2016; Yoshida et al., 2013). Observing the pain ratings derived from others may generate specific pain-related expectancies in the observer that affect the perception of upcoming pain (Koban et al., 2019). Unlike previous studies in which this type of pain-related information preceded the pain experience (Koban & Wager, 2016; Koban et al., 2019; Yoshida et al., 2013), in the current study this information followed the pain experience, which allowed us to investigate whether it could alter the memory of pain.

Regardless of the study group, the initial pain was remembered as less intense than it actually was. This result is in line with previous findings showing that acute pain associated with a positive event (e.g. giving birth, sports activity) tends to be underestimated (Bąbel et al., 2015, 2018). Some research data suggests that this may also apply to pain induced during an experiment, that is, an event in which a person participates voluntarily (Bąbel, 2017; De Pascalis et al., 2008; Fors & Götestam, 1996).

The obtained results did not confirm the hypothesis that the memory of pain changes as a result of information on pain derived from other people. It appears that one reason for the lack of this effect may be the nature of the pain induced in the participants. If the memory of experimental pain tends to fade naturally over time, the information on pain provided to participants may not have significantly differed from their actual pain expectancies. There is some evidence that information from external sources may have a greater effect on an individual if it is incongruent with their expectancies (Stangor & McMillan, 1992). It is assumed that this kind of information needs to be more deeply elaborated to justify the perceived incongruence and, therefore, might be better remembered.

The obtained results may also be due to the nature of the pain information provided to participants. In the current study, participants were informed that other people felt less pain than they did. This information might be less relevant to participants than information suggesting that the same pain was perceived by others as more intense. The relevance of cues suggesting pain exacerbation has been demonstrated in placebo studies which showed that nocebo hyperalgesia was easier to elicit than placebo analgesia (Colloca et al., 2010). Moreover, information suggesting pain exacerbation could abolish previously induced placebo analgesia (Benedetti et al., 2003) and even reverse the effects of analgesics (Aslaksen et al., 2015; Bingel et al., 2011). On the other hand, the upward information about other people's judgements that was used in another experimental study to alter the memory of the frequency of somatic and psychological symptoms was also shown to be ineffective (Merckelbach et al., 2018). However, it cannot be ruled out that information on pain from external sources would affect the memory of less-predictable acute pain. Information related to an experience that elicited severe arousal and negative affect may be better attended, encoded, and therefore better remembered (Kensinger, 2009).

In our study, pain ratings from other people were found to affect participants' subsequent pain experience. Participants provided with information that the pain they had previously experienced was rated by other people as less intense felt less pain when the same stimulus was applied again after a delay. This result aligns with previous studies showing the importance of social information in shaping responses to pain (Koban & Wager, 2016; Koban et al., 2019; Yoshida et al., 2013). However, while previous studies showed that this type of pain-related information influences how a novel pain stimulus is experienced, the current study demonstrated that it could alter subsequent responses to the same pain stimulus. Moreover, the effect of such information can occur even after a delay: in the present study, it was observed half an hour after the information on pain was presented. In order to determine the predictors of the different outcomes observed in both groups, we performed a hierarchical regression analysis. The results of this analysis confirmed the main ANOVA outcome showing that participants in the experimental group experienced less pain during the subsequent stimulation than those in the control group. However, this analysis did not reveal any differences in the predictors of the effects obtained in each group, showing that the first pain experience predicted the response to the subsequent pain in both groups. It should be emphasized that the sample

size in this study was calculated for ANOVA purposes and might not be sufficient for hierarchical regression analysis. Thus, this lack of differences can result from the underpowered sample.

The finding of this study has important implications for clinical practice. Patients deal with a wide variety of social information about pain. It seems that directing patients' attention to information provided by people who experienced less pain associated with the relevant treatment could be beneficial in reducing their pain associated with this treatment, thus maintaining their involvement in therapy. On the other hand, it seems crucial to protect people suffering from pain against information suggesting that other people perceived the same pain as more intense or unpleasant. This is especially important in the light of previous data showing that upward suggestions may be more effective than downward suggestions in shaping responses in those who receive them (Colloca et al., 2008; Merckelbach et al., 2018).

Significantly, information on pain provided by other people affected subsequent pain experiences in participants from the experimental group, regardless of their conformity and susceptibility to social influence. This result may be supported by previous findings indicating that in addition to influencing the participants' ratings, this type of manipulation may also cause changes in their neurophysiological responses (Koban et al., 2019). Similarly, the changes in pain experience were not related to participants' empathy. This result is in line with previous research suggesting that empathy contributes to changes in pain sensations when a person who is experiencing pain and rates its intensity is observed directly (Hunter et al., 2014).

To the best of our knowledge, this research is the first to investigate the impact of pain information provided by others on shaping pain memories and subsequent pain experiences. The detailed screening procedure made it possible to control for many potential confounders, such as age, mood, or health problems. The numbers of women and men in both groups were balanced, which seems to be important in the light of the existing data on the role of sex differences in pain perception (Racine et al., 2012). Moreover, the scales allegedly presenting pain ratings derived from other participants were based on the individual's initial pain report, thus making them more realistic. The individual differences were measured to determine whether they were related to susceptibility to the social information used in the study.

Some limitations of the current study should be acknowledged and addressed in future studies. First, the pain was examined in a laboratory setting; therefore, the results of this study should be generalized to the clinical population with caution. However, it seems that social information concerning pain may be much more effective in altering clinical pain, which is less predictable and controllable than experimentally induced pain. The evidence for this is provided by placebo studies showing that patients benefit from placebo treatment to a greater degree than healthy individuals (Forsberg et al., 2017). Second, the variables relied on self-reports, since there are no objective markers of nociception or pain (Cowen et al., 2015; Mouraux & Ianetti, 2018). Third, the sample size was calculated for the needs of the main analysis, that is, the within-between interaction. The number of participants was sufficient to fulfil the principal aims of the study, but it might not have been enough to detect a significant effect in the correlation analysis, especially when the Bonferroni correction for multiple comparisons was used. Fourth, for ethical reasons, participants were only presented with information that suggested that other people had felt less pain than they did. Thus, the study design does not allow answering the question of the effects produced by social information suggesting that the past pain was perceived as more painful by others. Fifth, because the study design required the inclusion of participants who gave a first pain intensity rating of 30 or more on the VAS, these results might refer in particular to those who are sensitive to pain.

In conclusion, the present findings show the importance of social information on pain. This type of information not only shapes the response to a novel stimulation but also substantially modifies the way the same pain stimulation is experienced after a period of time. These results may have important clinical implications. It seems that pain-related information provided this way can be used to improve the functioning of patients who undergo painful medical procedures regularly. It can alleviate pain associated with subsequent medical procedures and thus increase patients' willingness to continue treatment. Since pain is a social experience, further investigation into the role of social cues in these processes seems warranted.

AUTHOR CONTRIBUTIONS

EAB and PB conceptualized the study. EAB, JB, HB and PB designed the study. EAB, JB and HB conducted the study. JB and HB analysed the study results. EAB, JB, HB and PB interpreted the study results. EAB, JB, HB and PB drafted the manuscript. All authors discussed the results and commented on the manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

Adamczyk, W. M., Farley, D., Wiercioch-Kuzianik, K., Bajcar, E. A., Buglewicz, E., Nastaj, J., Gruszka, A., & Bąbel, P. (2019). Memory of pain in adults: A protocol for systematic review and meta-analysis. *Systematic Reviews*, *8*, 201.

Alberini, C. M., & Ledoux, J. E. (2013). Memory reconsolidation. *Current Biology*, *23*, R746–R750.

Aslaksen, P. M., Zwarg, M. L., Eilertsen, H.-I. H., Gorecka, M. M., & Bjørkedal, E. (2015). Opposite effects of the same drug: Reversal of topical analgesia by nocebo information. *Pain*, *156*, 39–46.

Bąbel, P. (2017). The effect of positive affect on the memory of pain. *Pain Management Nursing*, *18*, 129–136.

Bąbel, P., Bajcar, E. A., Śmieja, M., Adamczyk, W., Świder, K., Kicman, P., & Lisińska, N. (2018). Pain begets pain. When marathon runners are not in pain anymore, they underestimate their memory of marathon pain—A mediation analysis. *European Journal of Pain*, *22*, 800–809.

Bąbel, P., Pieniążek, L., & Zarotyński, D. (2015). The effect of the type of pain on the accuracy of memory of pain and affect. *European Journal of Pain*, *19*, 358–368.

Bajcar, E. A., Wiercioch-Kuzianik, K., Brączyk, J., Farley, D., Bieniek, H., & Bąbel, P. (2022). When one suffers less, all suffer less: Individual pain ratings are more effective than group ratings in producing placebo hypoalgesia. *European Journal of Pain*, *26*, 207–218.

Benedetti, F., Pollo, A., Lopiano, L., Lanotte, M., Vighetti, S., & Rainero, I. (2003). Conscious expectation and unconscious conditioning in analgesic, motor, and hormonal placebo/nocebo responses. *The Journal of Neuroscience*, *23*, 4315–4323.

Bingel, U., Wanigasekera, V., Wiech, K., Ni Mhuircheartaigh, R., Lee, M. C., Ploner, M., & Tracey, I. (2011). The effect of treatment expectation on drug efficacy: Imaging the analgesic benefit of the opioid remifentanil. *Science Translational Medicine*, *3*, 70ra14.

Bobier, D. M. (2002). *A easure of susceptibility to social influence: Scale development and validation*. University of Iowa.

Carter, L. E., McNeil, D. W., Vowles, K. E., Sorrell, J. T., Turk, C. L., Ries, B. J., & Hopko, D. R. (2002). Effects of emotion on pain reports, tolerance and physiology. *Pain Research & Management*, *7*, 21–30.

Chen, E., Zeltzer, L. K., Craske, M. G., & Katz, E. R. (2000). Children's memories for painful cancer treatment procedures: Implications for distress. *Child Development*, *71*, 933–947.

Colloca, L., Petrovic, P., Wager, T. D., Ingvar, M., & Benedetti, F. (2010). How the number of learning trials affects placebo and nocebo responses. *Pain*, *151*, 430–439.

Colloca, L., Sigaudo, M., & Benedetti, F. (2008). The role of learning in nocebo and placebo effects. *Pain*, *136*, 211–218.

Cowen, R., Stasiowska, M. K., Laycock, H., & Bantel, C. (2015). Assessing pain objectively: The use of physiological markers. *Anaesthesia*, *70*(7), 828–847.

Craig, K. D., & Prkachin, K. M. (1978). Social modeling influences on sensory decision theory and psychophysiological indexes of pain. *Journal of Personality and Social Psychology*, *36*, 805–815.

Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. JSAS Catalog of Selected Documents in Psychology *10*, 85.

De Pascalis, V., Cacace, I., & Massicolle, F. (2008). Focused analgesia in waking and hypnosis: Effects on pain, memory, and somatosensory event-related potentials. *Pain*, *134*, 197–208.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191.

Fors, E. A., & Götestam, K. G. (1996). The accuracy of memory for acute pain induction: An experimental study. *International Journal of Rehabilitation and Health*, *2*(4), 253–263.

Forsberg, J. T., Martinussen, M., & Flaten, M. A. (2017). The placebo analgesic effect in healthy individuals and patients: A meta-analysis. *Psychosomatic Medicine*, *79*, 388–394.

Gedney, J. J., & Logan, H. (2006). Pain related recall predicts future pain report. *Pain*, *121*, 69–76.

Goubert, L., Vlaeyen, J. W. S., Crombez, G., & Craig, K. D. (2011). Learning about pain from others: An observational learning account. *The Journal of Pain*, *12*, 167–174.

Gudjonsson, G. H. (1989). Compliance in an interrogative situation: A new scale. *Personality and Individual Differences*, *10*, 535–540.

Hadjistavropoulos, T., Craig, K. D., Duck, S., Cano, A., Goubert, L., Jackson, P. L., Mogil, J. S., Rainville, P., Sullivan, M. J. L., Williams, A. C. C., Vervoort, T., & Fitzgerald, T. D. (2011). A biopsychosocial formulation of pain communication. *Psychological Bulletin*, *137*, 910–939.

Hermesdorf, M., Berger, K., Baune, B. T., Wellmann, J., Ruscheweyh, R., & Wersching, H. (2016). Pain sensitivity in patients with major depression: Differential effect of pain sensitivity measures, somatic cofactors, and disease characteristics. *The Journal of Pain*, *17*, 606–616.

Hunter, T., Siess, F., & Colloca, L. (2014). Socially induced placebo analgesia: A comparison of a pre-recorded versus live face-to-face observation. *European Journal of Pain*, *18*, 914–922.

Kahneman, D., Fredrickson, B. L., Schreiber, C. A., & Redelmeier, D. A. (1993). When more pain is preferred to less: Adding a better end. *Psychological Science*, *4*, 401–405.

Kaźmierczak, M., Plopa, M., & Retowski, S. (2007). Skala Wrażliwości Empatycznej. *Przegląd Psychologiczny*, *50*(1), 9–24.

Kelly, A. (2001). The minimum clinically significant difference in visual analogue scale pain score does not differ with severity of pain. *Emergency Medicine Journal*, *18*, 205–207.

Kensinger, E. A. (2009). Remembering the details: Effects of emotion. *Emotion Review*, *1*, 99–113.

Koban, L., Jepma, M., López-Solà, M., & Wager, T. D. (2019). Different brain networks mediate the effects of social and conditioned expectations on pain. *Nature Communications*, *10*, 4096.

Koban, L., & Wager, T. D. (2016). Beyond conformity: Social influences on pain reports and physiology. *Emotion*, *16*, 24–32.

Marche, T. A., Briere, J. L., & von Baeyer, C. L. (2016). Children's forgetting of pain-related memories. *Journal of Pediatric Psychology*, *41*, 220–231.

Marks, D. F. (1973). Visual imagery differences in the recall of pictures. *British Journal of Psychology*, *64*(1), 17–24.

McNeil, D. W., & Rainwater, A. J. (1998). Development of the fear of pain questionnaire-III. *Journal of Behavioral Medicine*, *21*, 389–410.

Merckelbach, H., Dalsklev, M., van Helvoort, D., Boskovic, I., & Otgaar, H. (2018). Symptom self-reports are susceptible to misinformation. *Psychology of Consciousness: Theory, Research, and Practice*, *5*, 384–397.

Mouraux, A., & Iannetti, G. D. (2018). The search for pain biomarkers in the human brain. *Brain*, *141*(12), 3290–3307.

Noel, M., Chambers, C. T., McGrath, P. J., Klein, R. M., & Stewart, S. H. (2012). The influence of children's pain memories on subsequent pain experience. *Pain*, *153*, 1563–1572.

Pickrell, J. E., Heima, M., Weinstein, P., Coolidge, T., Coldwell, S. E., Skaret, E., Castillo, J., & Milgrom, P. (2007). Using memory restructuring strategy to enhance dental behaviour. *International Journal of Paediatric Dentistry*, *17*, 439–448.

Prkachin, K. M., & Craig, K. D. (1985). Influencing non-verbal expressions of pain: Signal detection analyses. *Pain*, *21*, 399–409.

Racine, M., Tousignant-Laflamme, Y., Kloda, L. A., Dion, D., Dupuis, G., & Choinière, M. (2012). A systematic literature review of 10 years of research on sex/gender and experimental pain perception—Part 1: Are there really differences between women and men? *Pain*, *153*, 602–618.

Redelmeier, D. A., Katz, J., & Kahneman, D. (2003). Memories of colonoscopy: A randomized trial. *Pain*, *104*, 187–194.

Sorokowska, A., Słowińska, A., Zbieg, A., & Sorokowski, P. (2014). Polska adaptacja testu Ten Item Personality Inventory (TIPI)—TIPI-PL—wersja standardowa i internetowa (WrocLab).

Stangor, C., & McMillan, D. (1992). Memory for expectancy-congruent and expectancy-incongruent information: A review of the social and social developmental literatures. *Psychological Bulletin*, *111*, 42–61.

Urban, E. J., Cochran, K. J., Acevedo, A. M., Cross, M. P., Pressman, S. D., & Loftus, E. F. (2019). Misremembering pain: A memory blindness approach to adding a better end. *Memory & Cognition*, *47*, 954–967.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063–1070.

Yoshida, W., Seymour, B., Koltzenburg, M., & Dolan, R. J. (2013). Uncertainty increases pain: Evidence for a novel mechanism of pain modulation involving the periaqueductal gray. *The Journal of Neuroscience*, *33*, 5638–5646.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, *67*, 361–370.

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