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MEMORY OF DENTAL PAIN INDUCED BY TOOTH RESTORATION*

The aims of the study were to assess the memory of dental pain induced by tooth restoration and to investigate the factors that influence the memory of pain. Two dimensions of pain, i.e., pain intensity and pain unpleasantness, were measured twice: immediately after dental treatment and at 6 or 12 weeks follow up. Regardless of the length of the recall delay, mean pain was recalled accurately, but mean pain unpleasantness was underestimated. However, underestimation of pain intensity and unpleasantness at the follow-up was observed only in the subjects who reported more intense and unpleasant pain immediately after dental treatment. Moreover, those who underestimated pain intensity and/or unpleasantness had higher scores on dental anxiety and reported more state anxiety and less positive affect before dental treatment.

Keywords: affect, anxiety, dental treatment, memory, pain

INTRODUCTION

The diagnosis and the decision about pain treatment are very often based on how a patient describes the past experience of pain. The effectiveness of pain treatment is sometimes assessed on the basis of relief that the patient reports after the treatment. The latter depends on the difference between present pain and the remembered pretreatment pain. The distortions of pain memory can not only be the problem in the proper diagnosis of pain and, hence, the decisions about treatment, but most of all may reduce the assessment reliability of the treatment effectiveness.

Feine, Lavigne, Thuan Dao, Morin and Lund (1998) analyzed data from clinical trials of analgesics and demonstrated that although the majority of patients reported pain relief, in fact, after the treatment their pain increased. The remembered pain was in fact overestimated in comparison to the pain actually experienced, because of which – compared to the pain experienced at the time – participants seemed to be feeling the improvement. De Pascalis, Chiaradia and Carotenuto (2002) and Price et al. (1999) basing on the measurement of the memory of pain obtained a much stronger placebo effect than on the basis of the measurement of pain intensity during the experiment, because after the completion of the study, the pain without the use of placebo was overestimated. In contrast, Everts et al. (1999) found that more than half of the participants who claimed that during hospitalization they felt complete relief from pain, did not remember this after six months, because

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then the remembered pain was overestimated compared to what it actually was during their stay in hospital.

The memory of pain also influences the subsequent experience of pain. Firstly, the remembered, rather than actual intensity of previously experienced pain affects the intensity of the following pain experience (Gedney & Logan, 2006; Noel, Chambers, McGrath, Klein, & Stewart, 2012a). In this way the remembered experiences of pain from childhood affect pain experience in adulthood (Pate, Blount, Cohen, & Smith, 1996). Secondly, the distorted pain memory increases the stress experienced during subsequent painful procedures (Chen, Zeltzer, Craske, & Katz, 2000). Thirdly, the memory of pain experienced during painful medical or experimental procedures influences the decisions concerning undergoing these procedures in the future (Kahneman, Fredrickson, Schreiber, & Redelmeier, 1993; Redelmeier, Katz, & Kahneman, 2003). Fourthly, the memory of post-operative pain is the predictor of chronic pain development (Tasmuth, Kataja, Blomqvist, von Smitten, & Kalsø, 1997; Tasmuth, von Smitten, Hietanen, Kataja, & Kalsø, 1995).

ACCURACY AND FACTORS INFLUENCING THE MEMORY OF PAIN

There is growing evidence that the memory of pain is distorted, though so far the results are varied. On one hand, the results of the research indicate that with time the pain is overestimated. This result was obtained in the case of chronic pain (Broderick et al., 2008; Stone, Schwartz, Broderick, & Shiffman, 2005; de Wit et al., 1999), acute pain (Algom & Lubel, 1994; Everts et al., 1999) as well as experimentally induced pain (De Pascalis et al., 2002; Gedney & Logan, 2006; Price et al., 1999). On the other hand, there is data showing that the pain may also be underestimated. Though, the last result is rare and sometimes is found in cases of acute (Norvell, Gaston-

Johansson, & Fridh, 1987) and experimental pain (De Pascalis, Cacace, & Massicolle, 2008), but not in chronic one. Much more data indicates the lack of differences between the remembered and the actual chronic (Bolton, 1999; Lefebvre & Keefe, 2002), acute (Singer, Kowalska, & Thode, 2001; Terry, Niven, Brodie, Jones, & Prowse, 2007) and experimental pain (Jantsch et al., 2009; Terry, Brody, & Niven, 2007).

Such large differences in the results of research on the memory of pain lead to search for factors that influence it. Most of the data indicates that the memory of the pain depends on the mean intensity of the experienced pain (Jantsch et al., 2009; Noel, Chambers, McGrath, Klein, & Stewart, 2012b; Schneider, Stone, Schwartz, & Broderick, 2011), the peak and the end of pain (Redelmeier & Kahneman, 1996; Redelmeier et al., 2003; Stone, Broderick, Kaell, DelesPaul, & Porter, 2000), the length of delay between the pain experience and its recall (Broderick et al., 2008; Feine et al., 1998) and the intensity of pain felt at the moment of recall (Bryant, 1993; Feine et al., 1998; Holroyd, France, Nash, & Hursey, 1993). Few studies that have investigated the relationship between the memory of pain and psychological factors emphasize the importance of expectations (De Pascalis et al., 2002; Price et al., 1999; Terry & Gijsbers, 2000) and of negative emotions: state anxiety (Everts et al., 1999; Noel et al., 2012b) and stress (Chen et al., 2000; Everts et al., 1999).

MEMORY OF DENTAL PAIN

Most of the seven previously published studies on the memory of dental pain indicate that dental pain is either overestimated (Eli, Schwartz-Arad, & Ben-Baht Tuvim, 2003; Kent, 1985; McNeil et al., 2011) or remembered accurately (Beese & Morley, 1993; Rocha, Marche, & von Baeyer, 2009). Eli, Baht, Kozlovsky and Simon (2000), due to the lack of pain measurement after treatment, and Gedney, Logan and Baron

(2003), due to the use of two different methods for the rating of the pain experience and the memory of it, were unable to determine whether there are differences between the experienced and remembered pain.

As for the factors influencing the memory of dental pain, positive although mostly moderate correlations between the remembered pain and state anxiety experienced before dental treatment (Eli et al., 2000; Gedney et al., 2003), immediately after the treatment (Eli et al., 2003; Rocha et al., 2009), but also at the time of pain recall (Eli et al., 2000, 2003) were observed. Moreover, the remembered anxiety correlated with remembered pain (McNeil et al., 2011). The remembered dental pain was found to correlate with trait anxiety, and the participants who overestimated the remembered pain compared to the experienced pain, were characterized by higher levels of trait anxiety than those who accurately remembered the pain (Rocha et al., 2009). There is also evidence that people with high dental trait anxiety distort the remembered pain more (Kent, 1985). It should also be noted that a correlation between the remembered pain, experienced pain (Eli et al., 2000; Gedney et al., 2003; Kent, 1985; McNeil et al., 2011; Rocha et al., 2009) and expected pain (Gedney et al., 2003; Kent, 1985) was found.

THE AIMS OF THE PRESENT STUDY

Most previous research on the memory of dental pain was related to pain caused by invasive procedures such as root canal therapy (Gedney et al., 2003), tooth extraction (Beese & Morley, 1993; McNeil et al., 2011), tooth crown lengthening (Eli et al., 2000), or implant insertion (Eli et al., 2003). Two studies focused on a variety of dental procedures and they were either not specified by the authors (Kent, 1985), or limited to a few examples (Rocha et al., 2009). Therefore, the first and main aim of our study was to determine the specificity of the memory of dental pain caused by one type of treatment, less invasive, but most often performed in a dental office, namely tooth restoration. What is particularly important, we decided to investigate the memory of the two dimensions of dental pain, i.e., pain intensity and pain unpleasantness. In the previous studies only Gedney and collaborators (2003) have measured both dimensions of pain, but due to the above-mentioned use of two different methods of the measurement of the experience of pain and the memory of it, it was not possible to determine if there are differences between the experienced and remembered pain.

The second aim of our study was to determine the factors that influence the memory of dental pain. First of all, we wanted to test the effect of the length of delay between treatment and the recall of pain caused by the treatment on the memory of pain. Although two previous studies on the memory of dental pain (Eli et al., 2000; Gedney et al., 2003) included two different delays, the memory of pain measurement was performed on each subject twice, and therefore the first measurement could have affected the second one, and beyond that – as mentioned above – it was not possible to determine whether there are differences between the experienced and remembered pain. We also decided to verify whether the memory of dental pain is affected by the experienced pain and affect. In the latter case, in contrast to previous studies, we measured not only negative affect, including the trait anxiety and state pain anxiety but also positive affect. We assumed that even painful treatment, which relieves pain or discomfort caused by the carious cavity, may also bring positive emotions.

METHOD

Participants
A total of 40 patients of private dental practice, including 20 females and 20 males with a carious cavity were involved in the first phase of the study. The subjects were randomly

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assigned to two groups: those with 6 and 12 weeks delay between the first and the second phase of the study. Each group consisted of 10 females and 10 males. In the second phase of the study a total of 35 people from the previous phase of the study were involved. The other five could not be contacted. The analysis includes the results of 35 people who participated in both phases of the study, including 18 females and 17 males, aged from 20 to 60 years ($M = 41.3$, $SD = 13.46$), who previously held no more than five visits to the dentist in the office where the study was conducted ($M = 2.77$, $SD = 1.69$). The first group (6-week delay) consisted of 18 people, including 9 females and 9 males, while the second group (12-week delay) consisted of 17 people, including 9 females and 8 males.

Materials

Dental Anxiety Scale (DAS) (Corah, 1969; Corah, Gale, & Illig, 1978) was used in the study. The scale measures the trait anxiety associated with dental procedures. It consists of four short questions, with five possible answers, for which subjects receive from 1 to 5 points. In total, it is possible to receive from 4 to 20 points. Gaining 20 points indicates an extremely severe dental phobia.

To measure state pain anxiety, intensity and unpleasantness of pain, and memory of the intensity and unpleasantness of pain, the authors used a Numeric Rating Scale (NRS) ranging from 0 to 10, where 0 indicated – depending on the measured variable – no anxiety / no pain, and 10 – the most intense pain imaginable / the most unpleasant pain imaginable / the most intense anxiety imaginable. Participants were to select the digit that reflected the severity of anxiety / intensity / unpleasantness of pain in the best way. In the first phase of the study the scales were preceded by instructions, in which participants were asked to rate the level of pain anxiety felt at the moment, and the intensity and the unpleasantness of pain experienced during dental treatment. On the other hand, in the second phase

of the study all participants were asked to recall the pain experienced during the first phase of the study and to rate its intensity and unpleasantness. It was emphasized that the task is not to recall the way the person characterized the pain then, but how they remember those painful experiences now.

The Polish adaptation of the Positive and Negative Affect Scale (Watson, Clark, & Tellegen, 1988) was used to measure the affect (version S20; Brzozowski, 2010). PANAS consists of 20 items, naming different emotions and feelings, including 10 of a positive and 10 – negative character. The participant task is to rate on a scale ranging from 1 to 5, the extent to which each word describes how the participant feels now/at this time. The points are added up separately for words naming positive and negative emotions and feelings, thereby obtaining the results for positive (min. 10, max. 50) and negative affect (min. 10, max. 50).

Procedure

The subjects were initially verified by the dentist in terms of having carious cavity, as well as by gender, and number of their previous dental treatment visits, and then they were asked to participate in the study. All invited patients agreed to participate in the study. The dentist, always the same, handed them a description of the procedure and the informed consent form to participate in the study. After reading the description of the procedure, patients signed the consent. Before the treatment the subjects received DAS, NRS to rate the state pain anxiety and the PANAS. After completing the forms the treatment without any anesthesia was performed. Immediately after the dental treatment the subjects received two NRS to rate the intensity and unpleasantness of pain experienced during the treatment.

After – depending on the group – 6 or 12 weeks after the first phase of the study, the participants were contacted on the telephone and asked to rate the intensity and the unpleasantness

of pain experienced during the treatment on two NRS. In the first group the mean number of days after which the participants recalled the pain was 46.5 (SD = 2.3), and the second group – 85 (SD = 2.45).

Results

Statistical analyses were performed using the Statistica data analysis software system version 10. The significance of differences between the experienced and recalled pain intensity was tested using a repeated measures analysis of variance (ANOVA) design 2 (Rating: experienced pain, pain recall) x 2 (Delay: 6 weeks, 12 weeks). The main effect of both Rating factor ($F(1, 33)$ = 1.30, $p > 0.05$, η^2 = 0.04) (Fig. 1.), Delay ($F(1, 33)$ = 3.95, $p > 0.05$, η^2 = 0.11) and the interaction of Rating and Delay ($F(1, 33)$ = 0.41, $p > 0.05$, η^2 = 0.01) proved to be statistically insignificant.

To determine the significance of differences between the experienced and recalled pain unpleasantness a repeated measures analysis of variance (ANOVA) design 2 (Rating: experienced pain, recalled pain) × 2 (Delay of 6 weeks and 12 weeks) was conducted. The main effect of Rating factor was found statistically significant ($F(1, 33)$ = 4.34, $p < 0.05$, η^2 = 0.12). It indicated that the recalled pain unpleasantness (M = 2.14, SD = 2.09) was underestimated compared to the experienced pain (M = 3.31, SD = 3.31) (Fig. 1). The main effect of Delay factor ($F(1, 33)$ = 3.46, $p > 0.05$ η^2 = 0.09) and the interaction of Rating and Delay factors were found statistically insignificant ($F(1, 33)$ = 0.25, $p > 0.05$, η^2 = 0.008).

The analysis of the results obtained by individual participants revealed that – regardless of the results of the comparison between mean intensity and mean unpleasantness of pain experienced immediately after the treatment and after the delay for all participants – there were significant individual differences in the accuracy of the recall of pain intensity and unpleasantness. Accordingly, the participants were assigned to three groups: those who accurately recalled pain intensity (there was no difference between the rating of pain intensity after treatment and after the delay; N = 10) and those who overestimated the recalled pain compared to the pain rated immediately after treatment (N = 10) and those who underestimated the recalled pain compared to the pain rated immediately after treatment (N = 15). To determine whether differences in the
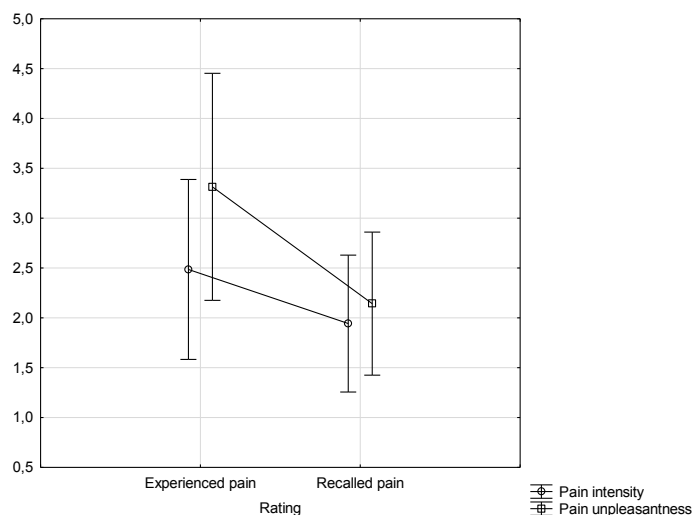

Fig. 1. Experienced vs. recalled intensity and unpleasantness of pain

experienced pain intensity may be responsible for the detected individual differences in the accuracy of the recalled pain, the three distinguished groups were compared in terms of the experienced pain level using one-way analysis of variance (ANOVA). As a result, it was found that there is a statistically significant difference between groups distinguished in terms of the experienced pain intensity ($F(2, 32) = 14.23$, $p < 0.001$, $\eta^2 = 0.47$). The participants who underestimated the recalled pain intensity, rated the experienced pain as significantly stronger ($M = 4.53$, $SD = 2.59$) compared to both the participants who accurately recalled pain intensity ($M = 1.10$, $SD = 1.45$, $F(1, 32) = 18.22$, $p < 0.001$, $\eta^2 = 0.36$) and those who overestimated the recalled pain ($M = 0.80$, $SD = 1.14$; $F(1, 32) = 21.54$, $p < 0.001$, $\eta^2 = 0.40$). There was no significant difference in the experienced pain intensity between subjects who overestimated the recalled pain intensity, and those who accurately recalled pain intensity ($F(2, 32) = 0.12$, $p > 0.05$, $\eta^2 = 0.004$) (Fig. 2).

Then the participants were assigned according to the accuracy of pain unpleasantness recall. On this basis, three groups were distinguished: those who accurately recalled pain unpleasantness (there was no difference between the rating

of post-treatment pain unpleasantness and the unpleasantness recalled after the delay; $N = 9$), those who overestimated the unpleasantness of the recalled pain compared to the unpleasantness reported immediately after treatment ($N = 10$), and those who underestimated the unpleasantness of the recalled pain compared to the unpleasantness felt immediately after treatment ($N = 16$). To determine whether individual differences in the accuracy of the pain unpleasantness recall may correspond to differences in the experienced pain unpleasantness, the three groups were compared in terms of the experienced pain unpleasantness using one-way analysis of variance (ANOVA) design. As a result, it was found that there is a statistically significant difference between groups distinguished in terms of the experienced pain unpleasantness ($F(2, 32) = 46.10$, $p < 0.001$, $\eta^2 = 0.74$). The participants who underestimated the recalled pain unpleasantness rated the experienced pain as significantly more unpleasant ($M = 6.38$, $SD = 2.25$) compared to both the participants who accurately recalled pain unpleasantness ($M = 1.00$, $SD = 1.50$; $F(1, 32) = 55.33$, $p < 0.001$, $\eta^2 = 0.63$) and those who overestimated the unpleasantness of the recalled pain ($M = 0.50$, $SD = 0.53$;
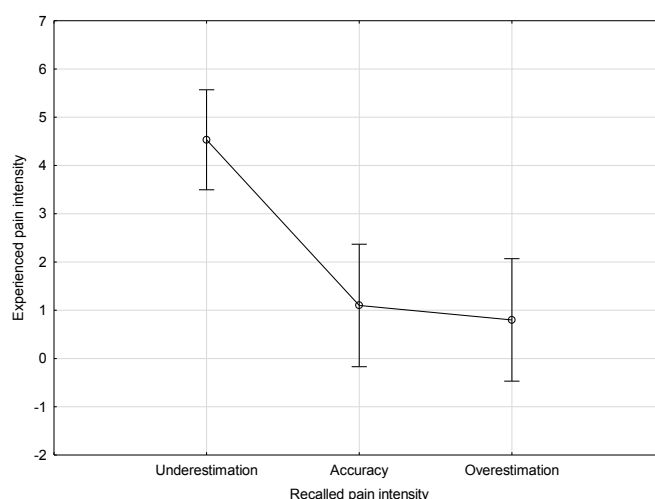

Fig. 2. Experienced pain intensity and its recall accuracy

$F(1, 32) = 70.62$, $p < 0.001$, $\eta^2 = 0.69$). There was no significant difference in the intensity of the experienced pain unpleasantness between the participants who overestimated the unpleasantness of the recalled pain, and those who accurately recalled pain unpleasantness ($F(2, 32) = 0.39$, $p > 0.05$, $\eta^2 = 0.01$) (Fig. 3).

In the next step of data analysis we examined whether individual differences found in the accuracy of recalling the intensity and unpleasantness of pain may correspond to differences in the level of affective variables. First, using one-way analysis of variance (ANOVA) we compared three groups (differing in terms of the accuracy of the pain intensity recall) in terms of the affective variables. There were no significant differences between the groups in the level of trait dental anxiety ($F(2, 32) = 1.49$, $p > 0.05$, $\eta^2 = 0.08$) and negative affect ($F(2, 32) = 0.44$, $p > 0.05$, $\eta^2 = 0.03$), but there were significant differences in the level of state pain anxiety ($F(2, 32) = 3.14$, $p = 0.057$, $\eta^2 = 0.16$) and positive affect ($F(2, 32) = 3.36$, $p < 0.05$, $\eta^2 = 0.17$). The participants who underestimated the recalled pain, felt more state pain anxiety ($M = 3.20$, $SD = 2.14$), compared to the participants who accurately recalled pain

intensity ($M = 1.20$, $SD = 1.48$; $F(1, 32) = 6.27$, $p < 0.05$, $\eta^2 = 0.16$). But there were no significant differences in the level of state pain anxiety between the participants who overestimated the recalled pain ($M = 2.40$, $SD = 2.07$), and those who accurately recalled pain intensity ($F(1, 32) = 1.88$, $p > 0.05$, $\eta^2 = 0.06$) and those who underestimated the recalled pain ($F(1, 32) = 1.00$, $p > 0.05$, $\eta^2 = 0.03$) (Fig. 4). The participants who underestimated the recalled pain, were characterized by significantly lower level of positive affect ($M = 19.40$, $SD = 9.34$), compared to the participants who accurately recalled pain intensity ($M = 28.10$, $SD = 10.32$; $F(1, 32) = 5.25$, $p < 0.05$, $\eta^2 = 0.14$), and – at trend level – compared to the participants who overestimated the recalled pain intensity ($M = 27.10$, $SD = 8.08$; $F(1, 32) = 4.11$, $p = 0.0509$, $\eta^2 = 0.11$). However, there was no significant difference in the level of positive affect between the participants who overestimated the recalled pain intensity, and those who accurately recalled pain intensity ($F(1, 32) = 0.06$, $p > 0.05$, $\eta^2 = 0.002$) (Fig . 5).

Then, using one-way analysis of variance (ANOVA) design three groups differing in terms of the accuracy of recalling pain unpleasantness were compared in terms of the affective
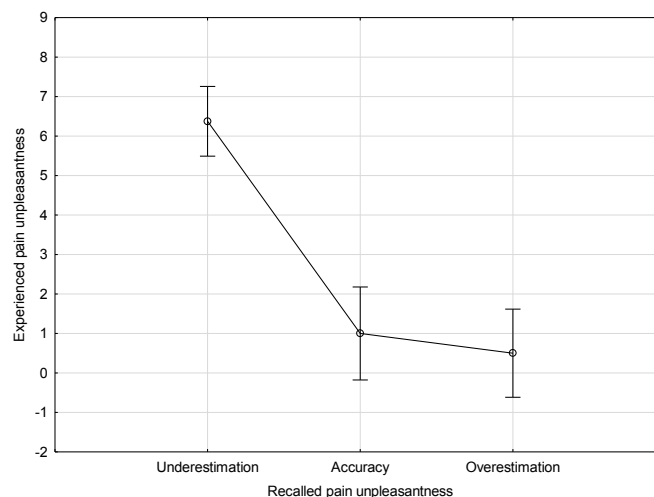

Fig. 3. Experienced pain unpleasantness and its recall accuracy

variables. There were no significant differences between the groups in the level of positive affect ($F(2, 32) = 1.89$, $p > 0.05$, $\eta^2 = 0.11$) and negative affect ($F(2, 32) = 0.70$, $p > 0.05$, $\eta^2 = 0.04$), but there were significant differences in the level of state pain anxiety ($F(2, 32) = 4.16$, $p < 0.05$, $\eta^2 = 0.21$) and – at trend level – trait dental anxiety ($F(2, 32) = 3.03$, $p = 0.06$, $\eta^2 = 0.16$). The participants who underestimated the recalled pain unpleasantness, were characterized by significantly higher level of trait dental anxiety ($M = 9.00$, $SD = 2.94$), compared to the participants who accurately recalled pain unpleasantness ($M = 6.44$, SD = 2.30; $F(1, 32) = 5.89$, $p < 0.05$, $\eta^2 = 0.16$). But there were no significant differences in the level of trait dental anxiety between the participants who overestimated the recalled pain unpleasantness ($M = 7.70$, $SD = 1.89$), and those who accurately recalled pain unpleasantness ($F(1, 32) = 1.17$, $p > 0.05$, $\eta^2 = 0.04$) and those who underestimated the recalled pain unpleasantness ($F(1, 32) = 1.63$, $p > 0.05$, $\eta^2 = 0.05$) (Fig. 6).
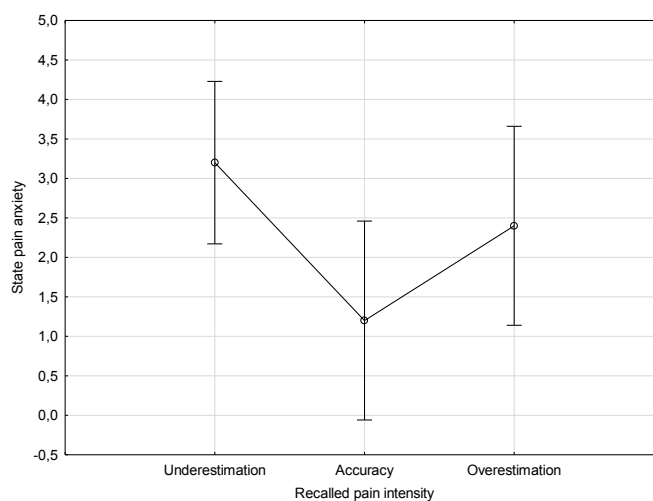

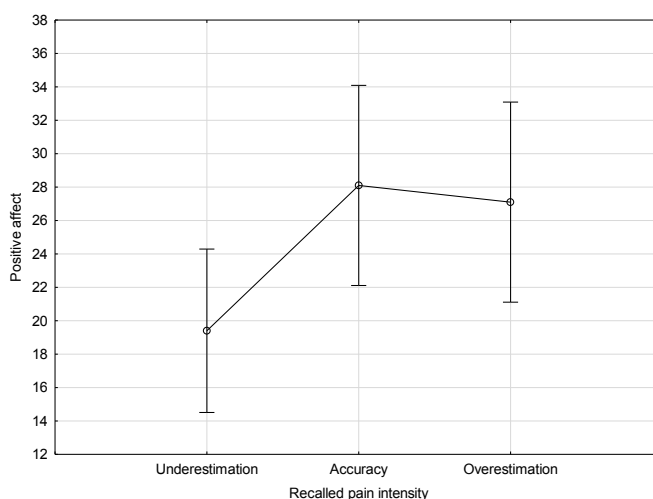Fig. 4. State pain anxiety and the accuracy of the recall of pain intensity

Fig. 5. The positive affect and the accuracy of the recall of pain intensity

The participants who underestimated the recalled pain unpleasantness, were characterized by significantly higher level of state pain anxiety ($M = 3.38$, $SD = 2.19$), compared to the participants who accurately recalled pain unpleasantness ($M = 1.22$, $SD = 1.56$; $F(1, 32) = 7.35$, $p < 0.05$, $\eta^2 = 0.19$), and – at trend level – in comparison to the participants who overestimated the recalled pain unpleasantness ($M = 1.90$, $SD = 1.66$; $F(1, 32) = 3.69$, $p = 0.06$, $\eta^2 = 0.10$). There was no significant difference in the level of state pain anxiety between the participants who overestimated the recalled pain unpleasantness and those who accurately recalled pain unpleasantness ($F(1, 32) = 0.60$, $p > 0.05$, $\eta^2 = 0.018$) (Fig. 7).

DISCUSSION

There was no significant difference between the experienced and recalled pain intensity, but pain unpleasantness was recalled as significantly
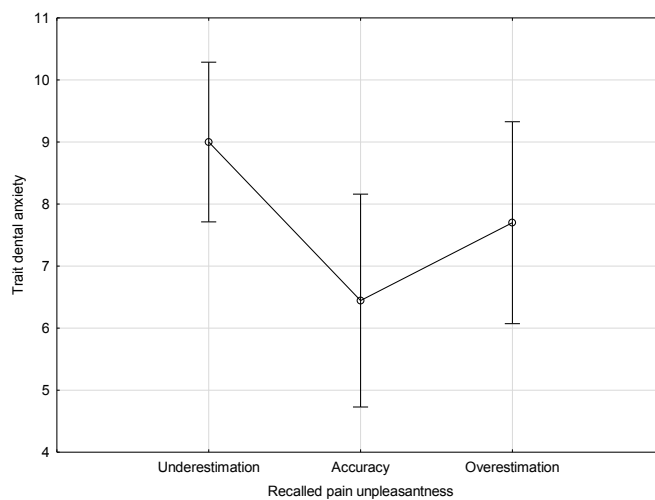

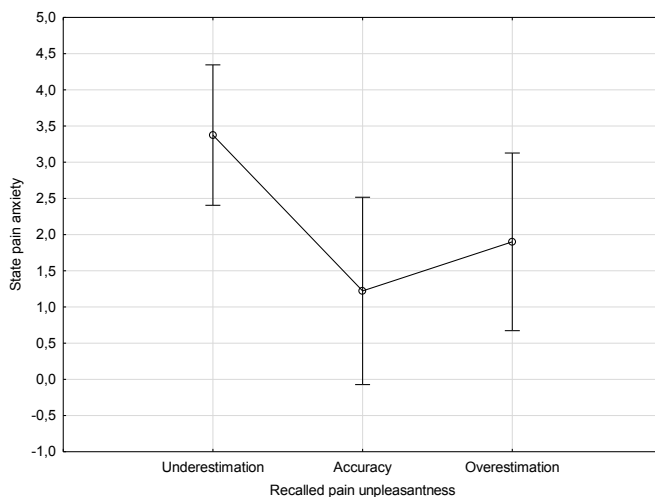Fig. 6. Trait dental anxiety and the accuracy of the recall of pain unpleasantness

Fig. 7. State pain anxiety and the accuracy of the recall of pain unpleasantness

lower than after treatment. These results, on one hand are consistent with the results of the studies indicating that the intensity of the pain caused by invasive dental treatments rather than by tooth restoration is recalled accurately (Beese & Morley, 1993; Rocha et al., 2009). On the other hand, demonstrating the memory distortions concerning the pain unpleasantness proves the independence of both dimensions of pain, and thus – the importance of the measurement of both the memory of the intensity and the unpleasantness of pain. Given the role of affect in the memory of pain – as shown in the present study – different results of the measurement of the memory of intensity (sensory dimension) and unpleasantness (affective dimension) of pain may be expected. It is to be emphasized that significant underestimation of the recalled pain unpleasantness compared to pain unpleasantness rated immediately after treatment and statistically insignificant, but seen in Figure 1, tendency to underestimation of the recalled pain intensity compared to the experienced pain intensity may be due to the fact that this study included the measurement of the memory of pain induced by a much less invasive procedure than in previous studies on dental pain.

No evidence was found that the length of the delay between the experience of pain and its recall influenced the memory of pain. From previous research on the memory of dental pain, in which two different delays were studied, it follows that the second rating of pain was underestimated (Eli et al., 2000), or pain intensity was recalled accurately, and the recalled pain unpleasantness was a little underestimated (Gedney et al., 2003). However, the design of the two studies allowed the comparison of the memory of pain in two time points in the same participants and without reference to their pain ratings immediately after treatment. The fact that there was no effect of the length of delay on the recalled pain may be the result of delays used in this study – 6 and 12 weeks. Eli and collaborators (2000) have demonstrated the change of the memory of pain

between 1 and 4 weeks after treatment, and Gedney and collaborators (2003) – the stability of the memory of pain between 1 week and 18 months after treatment. Based on previous research results and the results of this study we can, with caution, hypothesize that the memory of dental pain is stable between 6 and 12 weeks of delay.

The most important result of the study is the fact that we have found significant differences in the experienced pain intensity and pain unpleasantness depending on the accuracy of the recall of pain intensity and unpleasantness. We have found that the participants who underestimated the recalled intensity and unpleasantness of pain after the delay compared to the pain experienced just after tooth restoration, reported significantly higher intensity and unpleasantness of pain after the treatment than the participants who recalled the intensity and unpleasantness of pain accurately, and compared to the participants, who overestimated the recalled pain intensity and unpleasantness. The observed differences were found not only statistically significant, but also the magnitude of the effect was significant, especially in the case of pain unpleasantness ($\eta^2 = 0.74$). The results suggest that memory distortions in the form of underestimation of the intensity and unpleasantness of pain occurred only in the participants who experienced relatively strong ($M = 4.53$) and unpleasant pain ($M = 6.38$). Given the very low means of the experienced intensity and unpleasantness of pain among the participants who recalled pain accurately ($M = 1.10$ for intensity and $M = 1.00$ for unpleasantness) or overestimated the recalled intensity ($M = 0.80$) and unpleasantness of pain ($M = 0.50$), it would be difficult to expect underestimation of the intensity and unpleasantness of pain after the delay. Although previous research on the memory of dental pain show correlations between the recalled and the experienced intensity / unpleasantness of pain (Eli et al., 2000; Gedney et al., 2003;

Kent, 1985; McNeil et al., 2011; Rocha et al., 2009), the results of this study indicate a cause-effect relationship between the two variables. In view of these results the recalled pain intensity and unpleasantness is underestimated when the experienced intensity/unpleasantness is relatively high.

Regarding the results of this study on the importance of affective variables for the pain recall, firstly, both the participants who underestimated the recalled pain and those who underestimated the unpleasantness of recalled pain, felt significantly stronger state pain anxiety, compared to the participants who accurately recalled the intensity and unpleasantness of pain, and – at the trend level ($p = 0.06$) – compared to the participants who overestimated the recalled pain unpleasantness. This finding is consistent with the results of other studies on the relationship between pre-treatment state anxiety and the memory of dental pain (Eli et al., 2000; Gedney et al., 2003).

Secondly, it was found that the participants who underestimated the recalled pain unpleasantness were characterized by significantly higher levels of trait dental anxiety, but only compared to the participants who accurately recalled pain unpleasantness. In previous studies on the memory of dental pain it was shown that people with high levels of trait anxiety are more susceptible to distortions of the memory of pain. Namely, they overestimated the recalled pain compared to the pain experienced immediately after treatment (Kent, 1985; Rocha et al., 2009). The results of this study, therefore, extend the previous findings, indicating that people with high levels of trait dental anxiety are also more susceptible to distortions of the memory of pain, i.e., underestimation of the recalled pain intensity compared to the pain intensity experienced immediately after treatment.

Thirdly, the participants who underestimated the recalled pain, were characterized by significantly lower level of positive affect compared to the participants who accurately recalled pain intensity, and – at the trend level – compared to the participants who overestimated the recalled pain intensity ($p = 0.0509$). The results of this study show, therefore, that distortions of the memory of pain are associated not only with the increased level of negative affect (pain anxiety), but also with the low level of positive affect.

It is important to note the specificity and limitations of this study, which may have influenced the obtained results. First, dental pain induced by tooth restoration was studied, thus the results cannot be generalized to other types of pain, including other types of dental pain. Second, the obtained results were certainly influenced by the characteristics of the dentist who participated in the study. This is a person full of optimism and a positive attitude towards the world and people. Although all participants were treated by the same dentist and in addition, they did not know her very well, since before the study they had visited her dentist office no more than five times, the above-mentioned characteristics of hers may have had the effect on reduction of negative affect, including anxiety, and thus – feeling lower pain intensity and unpleasantness.

To summarize, the results of the study show that regardless of the length of the delay, the intensity of dental pain is relatively accurately recalled, but its unpleasantness is underestimated after a delay compared to immediately after treatment. Above all, however, it was shown that memory distortions of the intensity and unpleasantness of pain, that is underestimation of the intensity and unpleasantness of pain after the delay compared to the pain ratings immediately after dental treatment, were found only in those participants who at the time of treatment reported more intense and unpleasant pain. The results of the study show the importance of both high level of state pain anxiety and trait dental anxiety and low level of positive affect in the genesis of the distortions of the memory of pain in these participants.

Given the small number of previous studies, and above all, their mutually exclusive results, it is difficult to draw decisive conclusions. Future research should focus in particular on the influence of different lengths of delays between the experience of pain and its recall. It is important to remember to measure two dimensions of pain, because – as shown in this study – there are differences not only in the memory of them, but also in factors that influence them.

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