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Paweł Kicman\*  
Przemysław Bąbel\*

### Delayed discounting of pain with and without monetary reward

**Abstract:** We investigated the effect of monetary rewards on the rate of pain discounting. Our aim, also, was to understand the effect of previous painful dental experiences on the rate of discounting pain. Two groups ( $N = 148$ ) completed a discounting task. In the first group, delayed pain was weaker than immediate pain, and in the second group delayed pain was stronger than immediate pain. Two conditions were studied: pain was either accompanied by a monetary reward or not. We found that people preferred immediate pain when it was weaker than delayed pain; however, when delayed pain was stronger than immediate pain, there was no clear preference. In both groups the preference for immediate pain was higher when pain was accompanied by a monetary reward. Previous painful experiences were not related to the rate of discounting. It was concluded that the preference for delayed pain depends on the intensity of pain, and it can be modified by rewards that accompany pain.

**Keywords:** discounting, pain, punishment, reinforcement, reward

#### Introduction

Discounting is a process in which the subjective values of reinforcements and punishments are decreased. There are several types of discounting, one of which is the discounting of delayed values, which refers to a preference for one of two possible reinforcements or punishments, i.e. an immediate one or a delayed one (Rachlin, Raineri, & Cross, 1991). Discounting can be measured in real or hypothetical situations, however previous studies have revealed that there is no difference between the rate of discounting of hypothetical and real monetary rewards (Johnson & Bickel, 2002; Lagorio & Madden, 2005; Madden et al., 2004; Madden, Begotka, Raiff, & Kastern, 2003). In short, study participants make a choice or series of choices between two different values of reinforcement (e.g. gain) or punishment (e.g. loss) in different conditions, e.g. \$10 now or \$100 tomorrow. There are other types of discounting – probabilistic, social (Rachlin, 1993), and effort discounting (Mitchell, 1999; Sugiwaka & Okouchi, 2004) – but delayed discounting seems to have been studied the most.

Most studies of discounting have used money as a reward (Foxall, Doyle, Yani-de-Soriano, & Wells, 2011; Green, Myerson, & McFadden, 1997; Jarmolowicz et al., 2014; Ostaszewski & Bialaszek, 2010; Rachlin et al., 1991; Weatherly, 2011). However, some studies have used more biological rewards, such as sexual intercourse (Holt, Newquist, Smits, & Tiry, 2014; Jarmolowicz et al., 2014) or food (Holt et al., 2014; Mischel, Shoda, & Rodriguez, 1989). Generally, the research on reinforcement discounting shows that people prefer immediate small rewards over delayed large rewards, i.e. the higher the rate of discounting, the greater the preference for immediate reinforcement (Rachlin et al., 1991). There are, however, a few studies that have focused on the discounting of punishments. It is important to note that for punishment, a faster discounting rate means a stronger preference for delayed punishments, i.e. the more delayed punishment is, the less severe it seems to be. That is why delayed punishment is preferred to immediate one.

A few studies on discounting of monetary losses (serving as punishments) show that the preference is opposite of that for the discounting of monetary gains

\* Jagiellonian University, Institute of Psychology, Pain Research Group, Kraków, Poland

Send correspondence and requests for reprints to: Przemysław Bąbel, Jagiellonian University, Institute of Psychology, Pain Research Group; ul. Ingardena 6, 30-060 Kraków, Poland; Tel: +48126341305 ext. 246; Fax: +48126237699; E-mail: przemyslaw.babel@uj.edu.pl

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(serving as reinforcements), i.e. delayed losses are preferred over immediate losses (Estle, Green, Myerson, & Holt, 2006; Ostaszewski & Karzel, 2002; Weatherly & Derenne, 2013). However, most of the previous studies on punishment discounting have dealt only with monetary losses. While money is a non-biological, conditioned stimulus, pain is a universal, biological, and unconditioned phenomenon (Macrae & Davies, 1999). For these reasons, pain seems to be an interesting potential punishment to study.

According to the International Association for the Study of Pain, pain is 'an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage' (Merskey & Bogduk, 1994). We can say with high probability that pain, behaviourally, is a punishment because its role is to avoid the behaviours that cause it.

Very few studies have been conducted on the discounting of pain. However, Story and collaborators (2013) recently conducted two experiments. In the first one, participants had to choose between real immediate and delayed pain that was inflicted by electric stimulation. In the second study, another group of participants had to choose hypothetical dental pain of varying intensity. The results indicated that there is, in fact, a preference to choose more intense pain sooner rather than later. The researchers tried to explain this finding in terms of the dread of future pain resulting from anticipation of that pain; however, they did not go into details on the mechanism of the effects of dread on the discounting of pain. Story and colleagues (2013) only suggested that dread, as the prospective sum of anticipated punishment, might work as a cue for behavioural suppression during the delay. This suggestion is based on the fact that prediction of shock can lead to a conditioned suppression, reducing the vigor of instrumental responding (Estes & Skinner, 1941). Other possibility suggested by Story and colleagues (2013) is that dread is a substitute for a stimulus and the observation that some cues associated with the prediction of pain (in that case) can elicit the pain itself.

Similar results to those obtained by Story and collaborators (2013) were found a few decades earlier by Hare (1966). He studied pain preference in psychopaths, non-psychopathic criminals, and non-criminals. Although psychopaths chose immediate pain in only 55% of situations, the rest of the participants revealed an explicit preference for immediate electric shock – they chose quicker pain in 82.3% of situations.

Although discounting of reinforcements and punishments seem to be very different behavioural processes, sometimes they can converge. Some examples are: (a) unpleasant work followed by payment for that work, (b) a painful procedure that results in recovery, and (c) risky investing in the stock market when an initial loss can produce a larger gain. It is difficult to study just one type of discounting (e.g. delayed discounting), as both reinforcement and punishment often come not only with a delay, but with risk (probabilistic discounting) or physical effort (effort discounting). It seems that the painful dental

procedure investigated by Story and colleagues (Story et al., 2013) is a good example of a situation in which delayed discounting of pain can be studied without the risk of being biased by effort, probabilistic, or social discounting.

In summary, previous studies indicate that people tend to choose delayed punishments over immediate punishments (Estle et al., 2006; Ostaszewski & Bialaszek, 2010; Weatherly & Derenne, 2013), but this is not the case when choices of pain are studied (Hare, 1966; Story et al., 2013). In most of the previous studies, delayed punishment was of a higher or equal value to the immediate punishment, similar to studies of the discounting of reinforcements. Thus, it is worth investigating the discounting of large delayed punishments as well as small ones, i.e. smaller or equal delayed values compared to the immediate value. Thus, the first aim of this study was to investigate the discounting rate of pain. It was hypothesized that there is a preference for immediate pain rather than for delayed pain, both when delayed pain is greater and smaller than immediate pain (H 1). Moreover, it was hypothesized that the discounting rate of pain is higher than it is expected when participants choose only delayed values (H 2).

Little is known about the effect of reinforcement on the discounting rate of pain. Ostaszewski and Bialaszek (2010) studied the discounting rate of losses combined with uncertain gain, but they did not compare this rate with the discounting rate of losses alone. Schrooten, Wiech and Vlaeyen (2014) studied discounting of changing values of pain and money combined, but like Ostaszewski and Bialaszek (2010) they didn't investigate discounting rates of pain and money separately, so it is not clear whether and how reinforcement (money) changed discounting rate of punishment (pain). There are theories concerning the discounting of sequences of reinforcements, but they do not consider punishments (Brunner & Gibbon, 1995). Thus, the second aim of the study was to investigate the role of reinforcement on pain discounting. As people generally tend to prefer both sooner pain and sooner reinforcement over delayed pain and reinforcement, it was hypothesized that monetary rewards for pain would increase the discounting rate of pain, i.e. participants would prefer pain combined with money even sooner than pain alone (H 3).

Our choices, like our other behaviours, are shaped by past consequences (Skinner, 1974). Moreover, when it comes to painful procedures (both medical and experimental), past experiences of pain – or in fact memories of those experiences – influence choices related to those procedures, e.g. choosing to undergo the same procedure in the future or not (Kahneman, 2003; Redelmeier & Kahneman, 1996; Redelmeier, Katz, & Kahneman, 2003). Thus, question emerges of whether previous pain experience is related to the rate of discounting pain? It seems that previous experience of intense pain will probably be positively associated with avoiding immediate pain, but because of other variables, like delay, probability or effort, and the context of pain, it is difficult to predict if this will always be the case. Thus, the third aim of the study was to investigate the relation between previous pain experiences and the discounting rate of pain. It was hypothesized that the

discounting rate of dental pain would be related to previous experience of dental pain (H 4).

## Methods

### Participants

A total of 148 volunteers completed the study. Of those who completed the study, 105 were females (71%). The mean age of the participants was 22.79 years ( $SD=2.84$ ). Participants were recruited by an announcement on Facebook and by snowball sampling. They were randomly assigned to one of two groups: less-pain-later and more-pain-later. The less-pain-later group consisted of 66 participants, who had a mean age of 22.74 years ( $SD=3.26$ ) and included 47 females (71%); the more-pain-later group consisted of 82 participants, who had a mean age of 22.83 years ( $SD=2.46$ ) and included 58 females (71%). All participants gave their informed consent. The study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).

### Materials and procedure

Two questionnaires were used in the study, both of which began by asking participants their sex and age. Next, the participants were asked to recall the most intense dental pain they had ever experienced and to rate that pain on an 11-point numeric rating scale (NRS), ranging from 0=no pain, to 10=the most intense pain they ever experienced. Then, participants were given a series of choices about experiencing pain, which asked them to decide whether they would prefer to experience pain of a specific intensity (from 0=no pain, to 10=most intense pain imaginable) now or later (the delays were a day, a week, a month, six months, and a year later). For both groups, immediate pain was increased incrementally by 1, from 1 out of 10 up to 10 out of 10 on the NRS. Thus, there were 10 choices for each of the five delays, so that participants made a total of 50 choices in the first part of the questionnaire (without reward) and 50 choices in the second part of the questionnaire (with reward). Order of those conditions was intentionally not counterbalanced, as the study was aimed to investigate how positive reinforcement, i.e. adding a desirable stimulus, influences pain discounting. Thus, the condition with reward needed to follow the condition without reward. If the condition with reward were followed by the condition without reward, then negative punishment would be studied, i.e. removing a desirable stimulus.

For the less-pain group, the delayed pain was always set at 3 out of 10, and for the more-pain group the delayed pain was always set at 8 out of 10 on the NRS. The following instructions were given:

*Please imagine that you must undergo a painful dental procedure, which lasts for 50 minutes. You can choose the date of the procedure, but depending on that date, the pain intensity will be different. The procedure is not urgent, so choosing a specific date brings no other consequences than a different intensity of pain. There are no other contraindications or difficulties related to reaching the*

*dentist. You have no plans or responsibilities that could prevent you from going to the dentist.*

*Example:*

*Pain intensity 1/10 now Pain intensity 8/10 in six months  
Where 0 = no pain, 10 = most intense pain imaginable.*

*Choosing, for example, 'Pain intensity of 1/10 now' means that you prefer the immediate procedure which will cause pain of an intensity equal to 1/10.*

After the participants completed the first part of the study, the following instruction was given:

*Please imagine the same situation as before, but this time immediately after the procedure you will be paid 200 PLN (about \$50) in cash.*

Although the delayed values of reinforcement or punishment in many previous studies were always equal to the highest value of the possible 'now' choice, we decided to choose 3 out of 10 and 8 out of 10 as the delayed values (instead of 10 out of 10). We did so because our pilot study found that when delayed pain was set at 1 out of 10 or 10 out of 10, participants changed their choices very rarely. Therefore, there was no possibility to observe a difference in the mean discounting rate between conditions without and with reward.

Each participant completed one of the two versions (less pain later or more pain later) of the two-part questionnaire using an online survey created in Limesurvey.

## Results

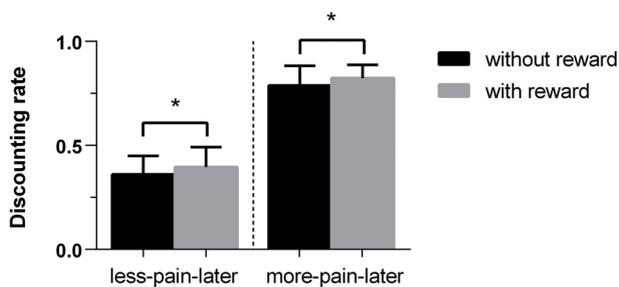
The discounting rate was calculated using the method proposed by Myerson, Green, and Warusawitharana (Myerson, Green, & Warusawitharana, 2001). The *area under the curve* (AUC) (i.e. an area under the empirical discounting function) was calculated. The first step was to determine the points of indifference, which are the means of the first value before changing one's decision and the first value after changing one's decision in a discounting task. The next step was to normalize those points and to normalize the values of delay, so that the points of indifference took values from 0 to 1 and the delay was expressed as a proportion of the maximum delay. Those normalized values were used as coordinates (x and y) to construct a graph of the discounting data. Vertical lines were drawn from each point, dividing the graph into a few trapezoids. The sum of the area of those trapezoids was the discounting rate. A small area means fast discounting, i.e. a preference for immediate reinforcement or punishment and vice versa (the larger the area, the slower the discounting, and the larger the preference for delayed reinforcement or for immediate punishment).

Excel 2013 was used to calculate the AUC and STATISTICA 12 was used for the rest of the statistical analyses.

A repeated-measures analysis of variance (ANOVA) was performed on AUC with group as a between-subject factor ('less pain later' and 'more pain later') and condition ('with reward' and 'without reward') as a within-subject factor. The ANOVA revealed a statistically significant main

effect of group ( $F_{(1,146)} = 1153.90, p < 0.001, \eta^2 = 0.89$ ) and a statistically significant main effect of condition ( $F_{(1,146)} = 28.21, p < 0.001, \eta^2 = 0.16$ ). No significant interaction between group and condition was found ( $F_{(1,146)} = 0.01, p = 0.91, \eta^2 = 0.01$ ). Planned comparisons revealed a statistically significant difference in AUC between the ‘without reward’ and ‘with reward’ conditions within both the less-pain-later group ( $F_{(1,146)} = 12.23, p < 0.001$ ) and the more-pain-later group ( $F_{(1,146)} = 16.45, p < 0.001$ ) (see Fig. 1). The mean discounting rate for the less-pain-later group in the ‘without reward’ condition was 0.36 ( $SD = 0.09$ ) and 0.40 ( $SD = 0.10$ ) in the ‘with reward’ condition. In the more-pain-later group, the mean discounting rate in the ‘without reward’ condition was 0.79 ( $SD = 0.09$ ) and it was 0.82 ( $SD = 0.06$ ) in the ‘with reward’ condition. These results indicate that participants preferred immediate pain more when it was accompanied by monetary reward than when pain was not accompanied by monetary reward.

**Figure 1. Discounting rate (AUC) for the less-pain-later group and the more-pain-later group in the ‘without reward’ and the ‘with reward’ conditions**



To examine whether the participants changed their choices in a different moment from a hypothetical situation in which the choice is changed when both options (delayed and immediate) are of the same value, Student’s t-tests were performed to compare obtained AUCs with expected AUCs. This was necessary to conclude whether the preference for delayed or immediate pain was observed. Expected AUCs were calculated as if participants chose only the least value of pain for every choice which produced AUC = 0.30 for less-pain-later group, and AUC = 0.80 for more-pain-later group. Thus, values over the expected AUCs indicate a preference for immediate pain and values below expected AUCs indicate a preference for delayed pain. For less-pain-later group there was a significant difference between obtained AUCs and expected AUCs for both ‘with reward’ condition ( $t = 8.04, p < 0.001, d = 1.41$ ) and ‘without reward’ condition ( $t = 5.61, p < 0.001, d = 0.87$ ), i.e. obtained AUCs were bigger than the expected AUCs. For more-pain-later group obtained AUC was bigger than expected AUC only in ‘with reward’ condition ( $t = 3.45, p < 0.001, d = 0.54$ ). These results suggest that there is a general preference for immediate pain when delayed pain is weaker than immediate pain. When delayed pain is stronger than immediate pain, there is no clear preference. However,

when pain is accompanied by monetary reward, immediate pain is preferred to delayed pain.

Linear regression found that the 0–10 rating of experienced dental pain did not predict the AUC in the less-pain group in the ‘without reward’ condition ( $\beta = -0.08, t = 64, p = 0.50; \text{Adj. } R^2 = -0.01, F_{(1,64)} = 0.44, p = 0.50$ ) or the ‘with reward’ condition ( $\beta = -0.23, t = 64, p = 0.06; \text{Adj. } R^2 = 0.04, F_{(1,64)} = 3.66, p = 0.06$ ). Moreover, the linear regression showed that the experienced dental-pain rating did not predict the AUC in the more-pain-later group in the ‘without reward’ condition ( $\beta = 0.02, t = 81, p = 0.86; \text{Adj. } R^2 = -0.01, F_{(1,64)} = 0.03, p = 0.86$ ) or the ‘with reward’ condition ( $\beta = -0.05, t = 81, p = 0.63; \text{Adj. } R^2 = -0.01, F_{(1,64)} = 0.23, p = 0.63$ ). Mean experienced dental pain in the less-pain-later group was 5.38 ( $SD = 1.87$ ), and in the more-pain-later group it was 5.88 ( $SD = 2.37$ ).

## Discussion

The results of our study indicate that people prefer immediate pain when the delayed pain is weaker, but this is not always the case when delayed pain is greater. Thus, we partially confirmed our hypothesis (H1) stating that there is a preference for immediate pain rather than for delayed pain, both when delayed pain is greater and smaller than immediate pain. However, we confirmed our hypothesis (H2) stating that the discounting rate of pain is higher than it is expected when participants choose only delayed values. These results are partially consistent with previous findings, which suggested that people tend to choose immediate pain over delayed pain (Hare, 1966; Story et al., 2013). It has been suggested that the dread caused by the anticipation of pain may be a crucial factor in the discounting of pain (Story et al., 2013). We speculate that dread might have influenced the preference for immediate pain. However, future research is needed to investigate the effect of dread on the discounting rate of high and low levels of pain.

Our study showed that delayed pain is discounted in a different way than that of the monetary losses that were discounted in previous research (Estle et al., 2006; Ostaszewski & Karzel, 2002; Weatherly & Derenne, 2013). If delayed punishments are higher or equal to immediate ones, as was the case in most of the previous studies on punishment discounting (Estle et al., 2006; Ostaszewski & Karzel, 2002; Weatherly & Derenne, 2013), delayed punishments are always the best choice from the perspective of the participant. An interesting question emerges: why are there different preferences for delayed losses and delayed pain if both of them are considered punishment, even though there is no such variability for different reinforcements? We can speculate that the key factor here could be the dread of future pain, as Story and colleagues suggested (Story et al., 2013). There might be no such dread of future loss in the case of monetary discounting or this dread could be less intense. Future research is needed to answer this question.

Novelty of our study is the fact that it seems to be the first to demonstrate that pain followed by money is discounted slower than pain alone. We confirmed our

hypothesis (H 3) stating that monetary rewards for pain would increase the discounting rate of pain, i.e. participants would prefer pain combined with money even sooner than pain alone. We speculate that monetary reward increased the preference for immediate pain because the reward was discounted when it accompanied delayed pain in contrast to the reward accompanying immediate pain. Thus, the reward was subjectively smaller when it accompanied delayed pain. As previous studies on discounting rates of punishment combined with reinforcement did not compare those rates with the discounting rates of punishment alone (Ostaszewski & Białaszek, 2010; Schrooten et al., 2014), our study is the first to show the effect of reinforcement on the discounting rate of punishment.

The results of this study may have important implications for medical practice. As reinforcement seems to impel people to choose sooner pain, patients could be encouraged to undergo a painful procedure (not only dental) sooner when they see clear benefits, which could possibly include non-monetary benefits that family or society, in general, can offer, especially social approval. Although an amount of 200 PLN (~\$50) was used as a reward in our study, future research is needed to investigate the effects of different amounts of money (both smaller and bigger) as well as different kinds of rewards (e.g. social approval from different people, i.e. family members, medical staff, strangers *etc.*) on the discounting rate of pain. We hypothesize that bigger amounts of money would increase the discounting rate of pain and that social approval would be more effective in increasing the discounting rate, especially when provided by medical staff members.

The results of our study did not support the idea that previous pain experience is related to the rate of pain discounting. Regardless of how people recalled their most intense pain, their experience was not related to their choices. Thus, although previous studies have found that past experiences of pain, i.e. memories of pain, influence choices related to painful medical and experimental procedures (Kahneman, 2003; Redelmeier & Kahneman, 1996; Redelmeier et al., 2003), we did not confirm our hypothesis (H 4) stating that the discounting rate of dental pain would be related to previous experience of dental pain. There probably is a variable or a set of variables, such as the number of dental procedures undergone, in general, or dread of dental procedures, which originated from previous experiences, that influenced the choices that we studied, and the relationship between discounting and previous pain experience probably is not based simply on the most intense pain recalled. Determining those variables could be a good direction for future studies.

Some limitations of our study should be acknowledged. First, we used only one value of reward in the form of money, so we do not know whether and how other monetary values or other possible reinforcements affect the discounting of pain. Second, we did not control for dread, which could be an important factor in discounting pain, as Story and colleagues suggested (Story et al., 2013). Third, the construction of the questionnaires extorted an unbalanced ratio of choices between weaker and stronger

pain, i.e. in the less-pain group, there were more choices in which immediate pain was stronger than delayed pain, and in the more-pain group, there were more choices in which delayed pain was weaker than immediate pain. Thus, other values of pain than 3 of 10 and 8 of 10 would potentially lead to different results. Fourth, our participants were mainly young adults, so we cannot generalize our results to older people. Moreover, 148 out of 322 participants who entered the study completed the whole procedure, which might have happened due to low motivation to complete an online survey or due to time-absorbing and wearying procedure. However, there is not clear evidence that both age and motivation to complete the online studies are moderators of discounting rate. Finally, monetary reward following painful dental procedure might not be ecologically valid. However, we aimed to use monetary reward as it is one of the most often studied reinforcements when it comes to delayed discounting (Foxall, Doyle, Yanide-Soriano, & Wells, 2011; Green, Myerson, & McFadden, 1997; Jarmolowicz et al., 2014; Ostaszewski & Białaszek, 2010; Rachlin et al., 1991; Weatherly, 2011). As a result, our findings may be related to the results of previous studies on the discounting of monetary rewards.

Discounting pain is an understudied issue that should be explored further. The process of changing the subjective value of pain is important for both theory and practice. Because punishments, particularly pain, are as important and common as reinforcements, we need to discover what variables influence decision making with regard to punishment. That knowledge should give us a useful tool for managing situations in which pain is inevitable, like dental procedures, or strong, as in unpleasant work. Knowledge of the effect of reinforcement on the discounting rate of pain could be used to develop strategies and methods aimed to encourage people to undergo painful procedures or situations, which they need to undergo, but which they may be afraid of because of the pain they would experience. For example, if future research finds which kind of reinforcements are the most effective in increasing the discounting rate of pain, those reinforcements may be used in clinical practice.

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