

# Does pain make people short-sighted? The impacts of physical and psychological pains on intertemporal choice

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## Abstract

We conducted three experiments to investigate the effects of physical and psychological pains on intertemporal choices. In Experiments 1 and 2, physical pain was induced by the self-created Shiatsu sheet treading method (SSTM) and the classical cold pressor task (CPT), respectively. In Experiment 3, psychological pain was induced by the video induction method. All types of pain increased preference for smaller immediate rewards. Theoretical implications and practical implications are discussed.

Keywords: physical pain, psychological pain, intertemporal choice

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## 1 Introduction

Pain has two-dimensional structure, including two components — physical pain and psychological pain. Psychological pain includes social pain, which is caused by social factors and denotes the feelings caused by damaged or broken social relations (such as suffering rejection and exclusion, being ignored by others, or experiencing the death of a loved one). Social pain is “the distressing experience arising from actual or potential psychological distance from close others or from the social group” (Eisenberger & Lieberman, 2014). Neurophysiological studies have provided evidences for the two-dimensional structure of pain, establishing that physical pain and psychological pain have overlapping neural circuitry. For example, the existing literature has shown that human brain provides similar neural alarm systems for physical pain and psychological pain, leading some studies to postulate the Social Pain/Physical Pain Overlap Theory (Eisenberger & Lieberman, 2004; Eisenberger et al., 2007).

The effect of pain on intertemporal choice has received some recent attention. For example, those experiencing migraine have been reported to be more impatient than a healthy control group (Wu et al., 2017). Likewise, the induction of acute thermal pain through injections of a stimulant into the forearm also rendered participants less patient (Koppel et al., 2017).<sup>1</sup> Those authors conjectured that pain increases preference for immediate monetary rewards by motivating its sufferers to seek immediate relief. Moreover, some recent studies demonstrated that physical pain degraded participants’ ability to envision remote places or traverse psychological distance, including the ability to plan for the future (Agerström et al., 2019). Few, if any, studies have shown that psychological pain has an impact on intertemporal choice.

This study attempts to add to this small body of research. Our first two experiments induce physical pain using the Shiatsu sheet treading method (SSTM) and the cold pressor task (CPT), respectively. In Experiment 3, we induce psychological pain using a documentary video clip.

## 2 Experiment 1 (SSTM)

In this experiment, 60 undergraduates (67% female;  $M_{\text{age}} = 20.4$  years,  $SD = 2.4$ ) recruited from two universities in western China were randomly assigned to a pain group or a control group. All participants were right-handed, and had never participated in similar studies, but formally consented to participate in this one. We used three domains: Money, Vacation

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to graduate and undergraduate lab assistants (Libo He, Chunmei Yang, Rong Zhang & Jin Pan) and all study participants.

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<sup>1</sup>However, Rassa et al. (2018) found no such effect in a study in which a burning sensation in the forearm was produced by via the application of topical capsaicin.

and Health. As described in the Appendix, the Health items were probably misleading, so we report results for Health only in the Appendix, for all three experiments.

## 2.1 Materials

To induce pain, we used a plastic Shiatsu sheet containing 162 hard protrusions, which is shown in Figure 1. Participants were asked to stand barefoot on this sheet.

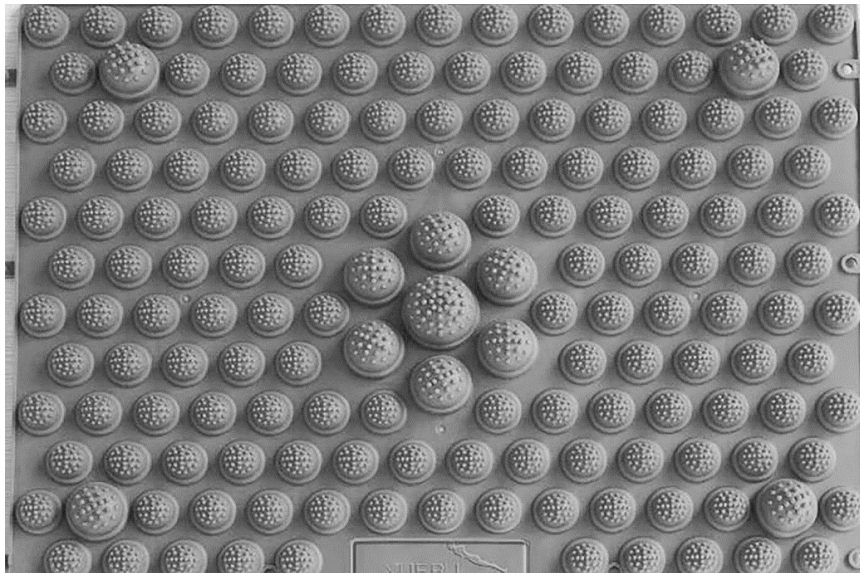


FIGURE 1: The Shiatsu sheet used as the pain inducing material in Experiment 1.

## 2.2 Experimental design and procedure

Respondents in all conditions made 27 choices between smaller immediate rewards and larger delayed rewards in each of three domains. Our monetary stimuli were similar but not identical to those used by Kirby et al. (1999). Table 1 shows the respective amounts (in Yuan), the delay (in days) and the imputed “k” value which is a metric of how impatient a respondent would have to be to choose the smaller more immediate reward. Analogous stimuli were created for the vacation and health domains (see Appendix for details).

After entering the laboratory, each participant was asked to rest and enter a calm state before starting the formal experiment to ensure a relatively calm baseline emotional state. Participants in the pain group were instructed to step barefoot onto the Shiatsu sheet — and report their pain intensity with Numerical Rating Scale (NRS, shown in Appendix, Part 5; Ferreira-Valente et al., 2011) which ranging from 0 (not at all painful) to 10 (extremely painful).<sup>2</sup> They were also asked to report their emotional state using

<sup>2</sup>Seventy healthy college students (59% female;  $M_{\text{age}} = 21.2$  years,  $SD = 1.6$ ) were recruited to assess physical pain intensity by NRS, and we found that 2-3 minutes on the Shiatsu sheet induced moderate physical pain ( $M = 5.74$ ,  $SD = 1.33$ ).

TABLE 1: Experimental materials of money domain in intertemporal choice task in Experiment 1.

Trial order	Reward amount (Yuan)		Delay time	k
	SIR	LDR		
13	340	350	186	0.00016
1	540	550	117	0.00016
9	780	800	162	0.00016
20	280	300	179	0.0004
6	470	500	160	0.0004
17	800	850	157	0.0004
26	220	250	136	0.001
24	540	600	111	0.001
12	670	750	119	0.001
22	250	300	80	0.0025
16	490	600	89	0.0025
15	690	850	91	0.0025
3	190	250	53	0.006
10	400	550	62	0.006
2	550	750	61	0.006
18	240	350	29	0.016
21	340	500	30	0.016
25	540	800	30	0.016
5	140	250	19	0.041
14	270	500	21	0.041
23	410	750	20	0.041
7	150	350	13	0.1
8	250	600	14	0.1
19	330	800	14	0.1
11	110	300	7	0.25
27	200	550	7	0.25
4	310	850	7	0.25

SIR = smaller, immediate reward; LDR = larger, delayed reward; delayed time = delays are in days.

the emotion self-assessment questionnaire. After this, while still standing on the Shiatsu sheet, the participants completed the 27 intertemporal choices for all the money, vacation

and health domains with a 3 min breaks in between (The presentation order of the three domains was counterbalanced among the participants). Participants in the non-pain group only reported their emotional state and made intertemporal choices. The post-interview results revealed that no participants guessed this study's objective.

After the experiment, each participant received a fixed payment of RMB 5 Yuan, and one half of 1% of the option they chose for one of the 27 trials in the money domain. As a result, the final payment for each participant ranged from RMB 5.55 - 9.25 Yuan.

## 2.3 Results

Table 2 displays the proportion of participants' impatient choices in each condition for each task type (In this experiment and later experiments, all decision results with health domain are presented in the Appendix). Those experiencing pain were more impatient in both domains ( $F(1, 57) = 27.30, p < .001, \eta_p^2 = .324$ ).

Basic results from the emotional self-assessment questionnaire are reported in the Appendix for this and other experiments. Several attempts to show that the responses mediated the effects of pain on intertemporal choice failed to show any significant mediation, in any of the three experiments. It is not clear that the negative results can be interpreted, as mediation analysis can fail for many reasons.

TABLE 2: The proportion of participants' impatient choices in each stimulus type (non-pain vs. pain) and task type (money vs. vacation) in Experiment 1.

	Money	Vacation
Non-pain	49%	45%
Pain	82%	68%

## 3 Experiment 2 (CPT)

We recruited 60 undergraduates (63% female;  $M_{\text{age}} = 20.4$  years,  $SD = 1.8$ ) from two universities in western China.

### 3.1 Experimental design and procedure

The experimental design, procedure and compensation were identical to Experiment 1, though in this study we induced physical pain using a CPT in which subjects must hold

their hand in cold water.<sup>3</sup> Once again, the post-interview results revealed that no participant guessed the objective of this study.

### 3.2 Results

Table 3 displays the proportion of participants' impatient choices in each condition for each task type. Those in pain were more impatient in both domains ( $F(1, 57) = 51.43, p < .001, \eta_p^2 = .474$ ).

TABLE 3: The proportion of participants' impatient choices in each stimulus type (non-pain vs. pain) and task type (money vs. vacation) in Experiment 2.

	Money	Vacation
Non-pain	38%	39%
Pain	78%	66%

## 4 Experiment 3 (Documentary Video Clip)

We recruited 68 undergraduates (51% female;  $M_{\text{age}}=21.0$  years,  $SD = 1.6$ ) from two universities in western China.

### 4.1 Materials

The experimental design, procedure and payment were similar to those used in the prior two experiments, except that we attempted to trigger psychological rather than physical pain and participant should assess intensity of psychological pain by an 11-point (0 = not at all painful, 10 = extremely painful) Distress Thermometer (DT, shown in Appendix, Part 7; Roth et al., 1998; National Comprehensive Cancer Network, 2003).<sup>4</sup> A Chinese documentary "human world" (the 9th episode) was shown to the participants of the pain group. In this video clip, the protagonist (Mrs. Zhang) is diagnosed with terminal pancreatic cancer when she is 5-month pregnant, so she is facing the prospect of saying goodbye to her loved ones, as well as feeling sorrow of missing the opportunity to see her child grow up.<sup>5</sup> Once again, no participants guessed the objective of this study.

<sup>3</sup>A total of 66 healthy college students (71% female;  $M_{\text{age}} = 21.0$  years,  $SD = 1.2$ ) were recruited to assess the pain induction intensity of CPT by NRS. The results revealed that CPT could induce high-intensity pain ( $M = 7.08, SD = 1.49$ ), and the duration was 2 - 3 min.

<sup>4</sup>No participant reported having experienced psychological pain within the last 6 months. Therefore, the interference of non-experimentally induced psychological pain on the experimental results can be eliminated.

<sup>5</sup>A total of 65 healthy college students (66% female,  $M_{\text{age}} = 21.0$  years,  $SD = 1.1$ ) were recruited, and evaluated the psychological pain of the aforementioned video on DT. The results revealed that the video material could induced considerable distress ( $M = 7.17, SD = 1.58$ ).

## 4.2 Results

Table 4 shows that the effect observed earlier extends to psychological pain: those participants forced to watch the sad video clip made more impatient choices in both domains ( $F(1, 66) = 203.58, p < .001, \eta_p^2 = .755$ ).

TABLE 4: The proportion of participants' impatient choices in each stimulus type (non-pain vs. pain) and task type (money vs. vacation) in Experiment 3.

	Money	Vacation
Non-pain	30%	33%
Pain	68%	76%

## 5 General discussion

In this study, the effects of pain on intertemporal choice were investigated from both physical and psychological aspects. We demonstrated that pain increases individuals' preference for more immediate rewards, making them exhibit a "short-sighted" decision-making tendency of the intertemporal choice, regardless of whether the pain is physical or psychological.

We found that physical pain could make individuals more immediate satisfaction on intertemporal choice. This result is mutually supportive of existing relevant findings. Becker et al. (2013) reported that physical pain increases individuals' motivation to obtain money benefits, and seeking instant gratification might be a compensatory response to pain because money benefits could reduce the subjective intensity of pain experience and unpleasant feeling. After that, Koppel et al. (2017) reported the effect of physical pain on intertemporal choice by inducing acute thermal pain, which confirmed the above conclusion. Besides the physical pain effect, the present study also found that the psychological pain can also make individuals more immediate satisfaction, established the consistent pattern of psychosomatic results under the pain state, and supported the Social Pain/Physical Pain Overlap Theory (Eisenberger & Lieberman, 2004; Eisenberger et al., 2007).

Pain may affect intertemporal choice mainly through two aspects. On the one hand, pain may result in negative emotional state, and participants will use immediate rewards as an analgesic to repair bad mood, so they are more likely to choose immediate options in the context of pain induction (Koppel et al., 2017). On the other hand, pain may cause individuals to increase their attention to pain-related stimuli, leading to a degree of attentional bias (Khatibi et al., 2009; Haggman et al., 2010). When pain occurs, as the dominant cue occupying the attention resource of individuals, decreasing it or eliminating it becomes the primary task of individuals, which would decrease the attention resource required by individuals to focus on other tasks (Eccleston & Crombez, 1999; Buffington et

al., 2005; Wager et al., 2013). This may make individuals more inclined to adopt the way of intuitive processing for intertemporal decision-making, and thus tend to instant satisfaction.

This study is the first time to prove the impact of psychological pain on intertemporal choice; the first time to find the cross-domain consistency of the pain effect on intertemporal choice based on the multiple domains perspective of decision-making; and establishes a new physical pain induction paradigm (SSTM) which is more convenient and safer than the classical paradigm (CPT), which has certain application value. However, this study also has some limitations. As we did not elucidate the internal mechanism of pain effect in intertemporal choice, we call for future research to investigate the role of emotions and cognitive resources, such as the role of attention in the pain effect on intertemporal choice. In addition, our scope of sampling was limited, comprised only college students, although who had the maximum cross-cultural consistency, the same level of individual education, and came from different socioeconomic status. Thus, the scope of application of the study conclusions might be also limited, suggesting future studies to use multiple samples to verify the stability of the pain effect on intertemporal choice in large population.

## References

- Agerström, J., Stening, K., & Axman, O. (2019). Pain here and now: physical pain impairs transcendence of psychological distance. *Journal of Pain Research, 12*, 961–968. <http://dx.doi.org/10.2147/jpr.s194114>.
- Becker, S., Gandhi, W., Elfassy, N. M., & Schweinhardt, P. (2013). The role of dopamine in the perceptual modulation of nociceptive stimuli by monetary wins or losses. *European Journal of Neuroscience, 38*(7), 3080–3088. <http://dx.doi.org/10.1111/ejn.12303>.
- Buffington, A. L., Hanlon, C. A., & Mckeown, M. J. (2005). Acute and persistent pain modulation of attention-related anterior cingulate FMRI activations. *Pain, 113*(1), 172–184. <http://dx.doi.org/10.1016/j.pain.2004.10.006>.
- Eccleston, C., & Crombez, G. (1999). Pain demands attention: a cognitive-affective model of the interruptive function of pain. *Psychological Bulletin, 125*(3), 356–366. <http://dx.doi.org/10.1037//0033-2909.125.3.356>.
- Eisenberger, N. I., & Lieberman, M. D. (2004). Why rejection hurts: a common neural alarm system for physical and social pain. *Trends in Cognitive Sciences, 8*(7), 0–300. <http://dx.doi.org/10.1016/j.tics.2004.05.010>.
- Eisenberger, N. I., Jarcho, J. M., Lieberman, M. D., & Naliboff, B. D. (2007). An experimental study of shared sensitivity to physical pain and social rejection. *Pain, 126*(1-3), 132–138. <http://dx.doi.org/10.1016/j.pain.2006.06.024>.
- Eisenberger, N. I., & Lieberman, M. D. (2014). Why it hurts to be left out: the neurocognitive overlap between physical and social pain. *Social Outcast Ostracism, 109*–127.
- Ferreira-Valente, M. A., Pais-Ribeiro, J. L., & Jensen, M. P. (2011). Validity of four pain intensity rating scales. *Pain, 152*(10), 2399–2404. <http://dx.doi.org/10.1016/j.pain.2011>.



07.005.

- Haggman, S. P., Sharpe, L. A., Nicholas, M. K., & Refshauge, K. M. (2010). Attentional biases toward sensory pain words in acute and chronic pain patients. *Journal of Pain*, *11*(11), 1136–1145. <http://dx.doi.org/10.1016/j.jpain.2010.02.017>.
- Khatibi, A., Dehghani, M., Sharpe, L., Asmundson, G. J., & Pouretamad, H. (2009). Selective attention towards painful faces among chronic pain patients: evidence from a modified version of the dot-probe. *Pain*, *142*(1-2), 42–47. <http://dx.doi.org/10.1016/j.pain.2008.11.020>.
- Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental Psychology: General*, *128*(1), 78–87. <http://dx.doi.org/10.1037/0096-3445.128.1.78>.
- Koppel, L., Andersson, D., Posadzy, K., Västfjäll, D., & Tinghög, G. (2017). The effect of acute pain on risky and intertemporal choice. *Experimental Economics*, *20*(4), 878–893. <http://dx.doi.org/10.1007/s10683-017-9515-6>.
- National Comprehensive Cancer Network (2003). Distress management. Clinical practice guidelines in oncology. *Journal of the National Comprehensive Cancer Network : JNCCN*, *1*(3), 344–374. <https://doi.org/10.6004/jnccn.2003.0031>.
- Rassu, F. S., Linsenbardt, H. R., Fields, S. A., & Meagher, M. W. (2018). Does pain affect preference? The effect of tonic laboratory pain on discounting of delayed rewards. *The Journal of Pain*, *19*(9), 962–972. <https://doi.org/10.1016/j.jpain.2018.03.007>.
- Roth, A. J., Kornblith, A. B., Batel-Copel, L., Peabody, E., Scher, H. I., & Holland, J. C. (1998). Rapid screening for psychological distress in men with prostate carcinoma. *Cancer*, *82*(10), 1904–1908. [https://doi.org/10.1002/\(SICI\)1097-0142\(19980515\)82:10<1904::AID-CNCR13>3.0.CO;2-X](https://doi.org/10.1002/(SICI)1097-0142(19980515)82:10<1904::AID-CNCR13>3.0.CO;2-X).
- Wager, T. D., Atlas, L. Y., Lindquist, M. A., Roy, M., Woo, C. W., & Kross, E. (2013). An fMRI-based neurologic signature of physical pain. *New England Journal of Medicine*, *368*(15), 1388–1397. <http://dx.doi.org/10.1056/NEJMoa1204471>.
- Wu, X. Q., Dai, Y. J., Ma, H. J., Bai, T. J., Gao, J. G., & Wang, K. (2017). Changes of intertemporal choice in migraine sufferers. *Chinese Journal of Behavioral Medicine and Brain Science*, *26*(3), 226–231. (in Chinese). <http://dx.doi.org/10.3760/cma.j.issn.1674-6554.2017.03.007>.

## Appendix

### Experimental materials

#### Part 1. Experimental Material of the Money Intertemporal Choice Task

Welcome to participate in this study! We promise that all information contained in this questionnaire is only for research and we will not disclose your information in any way.

This experiment requires you to choose between the amount you can get immediately and the amount you can get after a period of time (Please tick “√” in front of each item that

you think is appropriate. There are no right or wrong answers).

1. (A) Get 540 Yuan today; (B) Get 550 Yuan after 117 days.
2. (A) Get 550 Yuan today; (B) Get 750 Yuan after 61 days.
3. (A) Get 190 Yuan today; (B) Get 250 Yuan after 53 days.
4. (A) Get 310 Yuan today; (B) Get 850 Yuan after 7 days.
5. (A) Get 140 Yuan today; (B) Get 250 Yuan after 19 days.
6. (A) Get 470 Yuan today; (B) Get 500 Yuan after 160 days.
7. (A) Get 150 Yuan today; (B) Get 350 Yuan after 13 days.
8. (A) Get 250 Yuan today; (B) Get 600 Yuan after 14 days.
9. (A) Get 780 Yuan today; (B) Get 800 Yuan after 162 days.
10. (A) Get 400 Yuan today; (B) Get 550 Yuan after 62 days.
11. (A) Get 110 Yuan today; (B) Get 300 Yuan after 7 days.
12. (A) Get 670 Yuan today; (B) Get 750 Yuan after 119 days.
13. (A) Get 340 Yuan today; (B) Get 350 Yuan after 186 days.
14. (A) Get 270 Yuan today; (B) Get 500 Yuan after 21 days.
15. (A) Get 690 Yuan today; (B) Get 850 Yuan after 91 days.
16. (A) Get 490 Yuan today; (B) Get 600 Yuan after 89 days.
17. (A) Get 800 Yuan today; (B) Get 850 Yuan after 157 days.
18. (A) Get 240 Yuan today; (B) Get 350 Yuan after 29 days.
19. (A) Get 330 Yuan today; (B) Get 800 Yuan after 14 days.
20. (A) Get 280 Yuan today; (B) Get 300 Yuan after 179 days.
21. (A) Get 340 Yuan today; (B) Get 500 Yuan after 30 days.
22. (A) Get 250 Yuan today; (B) Get 300 Yuan after 80 days.
23. (A) Get 410 Yuan today; (B) Get 750 Yuan after 20 days.
24. (A) Get 540 Yuan today; (B) Get 600 Yuan after 111 days.
25. (A) Get 540 Yuan today; (B) Get 800 Yuan after 30 days.
26. (A) Get 220 Yuan today; (B) Get 250 Yuan after 136 days.
27. (A) Get 200 Yuan today; (B) Get 550 Yuan after 7 days.

## Part 2. Pre-experiment of the Vacation Intertemporal Choice Task

Welcome to participate in this study! We promise that all information contained in this questionnaire is only for research and we will not disclose your information in any way.

**Selective titration method:** Please imagine that you are a company employee. You draw a lottery ticket at the company's annual meeting. You can redeem the lottery ticket in two ways. (A) Enjoy a two-day off. (B) No vacation but can get a certain amount of cash rewards. Please select from the following 20 groups of options that you can accept (Please

tick “√” in front of each item that you think is appropriate. There are no right or wrong answers).

1. (A) Get 2 day vacation; (B) Get a 20 Yuan bonus.
2. (A) Get 2 day vacation; (B) Get a 40 Yuan bonus.
3. (A) Get 2 day vacation; (B) Get a 60 Yuan bonus.
4. (A) Get 2 day vacation; (B) Get a 80 Yuan bonus.
5. (A) Get 2 day vacation; (B) Get a 100 Yuan bonus.
6. (A) Get 2 day vacation; (B) Get a 120 Yuan bonus.
7. (A) Get 2 day vacation; (B) Get a 140 Yuan bonus.
8. (A) Get 2 day vacation; (B) Get a 160 Yuan bonus.
9. (A) Get 2 day vacation; (B) Get a 180 Yuan bonus.
10. (A) Get 2 day vacation; (B) Get a 200 Yuan bonus.
11. (A) Get 2 day vacation; (B) Get a 220 Yuan bonus.
12. (A) Get 2 day vacation; (B) Get a 240 Yuan bonus.
13. (A) Get 2 day vacation; (B) Get a 260 Yuan bonus.
14. (A) Get 2 day vacation; (B) Get a 280 Yuan bonus.
15. (A) Get 2 day vacation; (B) Get a 300 Yuan bonus.
16. (A) Get 2 day vacation; (B) Get a 320 Yuan bonus.
17. (A) Get 2 day vacation; (B) Get a 340 Yuan bonus.
18. (A) Get 2 day vacation; (B) Get a 360 Yuan bonus.
19. (A) Get 2 day vacation; (B) Get a 380 Yuan bonus.
20. (A) Get 2 day vacation; (B) Get a 400 Yuan bonus.

**Matching method:** Please fill in the horizontal line with a number representing the amount of money, and make you think that the two options are equivalent.

(A) Get 2 day vacation; (B) Get \_\_\_\_\_ Yuan bonus.

### Part 3. Experimental Material of the Vacation Intertemporal Choice Task

Welcome to participate in this study! We promise that all information contained in this questionnaire is only for research and we will not disclose your information in any way.

Please imagine that you are a company employee. You draw a lottery ticket at the company’s annual meeting. You can redeem the lottery ticket in two ways. (A) Get a period of vacation now. (B) Work after a period of time to get more vacation time. Please select from the following 27 groups of options that you can accept (Please tick “√” in front of each item that you think is appropriate. There are no right or wrong answers).

1. (A) Get 261 days of vacation now; (B) Get 266 days of vacation after 120 days.
2. (A) Get 266 days of vacation now; (B) Get 362 days of vacation after 60 days.
3. (A) Get 92 days of vacation now; (B) Get 121 days of vacation after 53 days.
4. (A) Get 150 days of vacation now; (B) Get 411 days of vacation after 7 days.
5. (A) Get 68 days of vacation now; (B) Get 121 days of vacation after 19 days.
6. (A) Get 227 days of vacation now; (B) Get 241 days of vacation after 154 days.
7. (A) Get 72 days of vacation now; (B) Get 170 days of vacation after 14 days.
8. (A) Get 121 days of vacation now; (B) Get 290 days of vacation after 14 days.
9. (A) Get 377 days of vacation now; (B) Get 387 days of vacation after 165 days.
10. (A) Get 193 days of vacation now; (B) Get 266 days of vacation after 63 days.
11. (A) Get 53 days of vacation now; (B) Get 145 days of vacation after 7 days.
12. (A) Get 324 days of vacation now; (B) Get 363 days of vacation after 120 days.
13. (A) Get 164 days of vacation now; (B) Get 170 days of vacation after 229 days.
14. (A) Get 130 days of vacation now; (B) Get 242 days of vacation after 21 days.
15. (A) Get 333 days of vacation now; (B) Get 411 days of vacation after 94 days.
16. (A) Get 234 days of vacation now; (B) Get 290 days of vacation after 96 days.
17. (A) Get 387 days of vacation now; (B) Get 411 days of vacation after 155 days.
18. (A) Get 116 days of vacation now; (B) Get 170 days of vacation after 29 days.
19. (A) Get 160 days of vacation now; (B) Get 387 days of vacation after 14 days.
20. (A) Get 135 days of vacation now; (B) Get 145 days of vacation after 185 days.
21. (A) Get 164 days of vacation now; (B) Get 241 days of vacation after 29 days.
22. (A) Get 121 days of vacation now; (B) Get 145 days of vacation after 79 days.
23. (A) Get 198 days of vacation now; (B) Get 363 days of vacation after 20 days.
24. (A) Get 261 days of vacation now; (B) Get 290 days of vacation after 111 days.
25. (A) Get 261 days of vacation now; (B) Get 387 days of vacation after 30 days.
26. (A) Get 106 days of vacation now; (B) Get 121 days of vacation after 142 days.
27. (A) Get 97 days of vacation now; (B) Get 266 days of vacation after 7 days.

#### **Part 4. Experimental Material of the Health Intertemporal Choice Task**

Welcome to participate in this study! We promise that all information contained in this questionnaire is only for research and we will not disclose your information in any way.

Please try to imagine that you have been in such a sub-health state lately:

According to your doctor's instructions, you need to take medication once a day. You must also be very careful about what you eat, so you spend a lot of time recording your daily food intake. In addition, you find that your frequency of going to the bathroom has increased. You often feel tired, and sometimes feel dizzy. When you sleep, you sometimes suffer from insomnia and sometimes you have nightmares. Your mouth sometimes feels dry, and food do not seem to have as much tastes as they used to. You seem to be uninterested

in anything, often angry or annoyed, and feel hard to concentrate.

If there are two choices, to return to the state of health immediately or to continue the sub-health state for a period of time but can obtain a longer state of health, please choose from 27 options below that you can accept (please tick “√” before each item you think is appropriate). There are no right or wrong answers.

1. (A) Return to health for 119 days today; (B) Return to health for 122 days after 158 days.
2. (A) Return to health for 122 days today; (B) Return to health for 166 days after 60 days.
3. (A) Return to health for 42 days today; (B) Return to health for 55 days after 52 days.
4. (A) Return to health for 69 days today; (B) Return to health for 188 days after 7 days.
5. (A) Return to health for 31 days today; (B) Return to health for 55 days after 19 days.
6. (A) Return to health for 104 days today; (B) Return to health for 111 days after 168 days.
7. (A) Return to health for 33 days today; (B) Return to health for 77 days after 13 days.
8. (A) Return to health for 55 days today; (B) Return to health for 133 days after 14 days.
9. (A) Return to health for 172 days today; (B) Return to health for 177 days after 182 days.
10. (A) Return to health for 88 days today; (B) Return to health for 122 days after 64 days.
11. (A) Return to health for 24 days today; (B) Return to health for 66 days after 7 days.
12. (A) Return to health for 148 days today; (B) Return to health for 166 days after 122 days.
13. (A) Return to health for 75 days today; (B) Return to health for 77 days after 167 days.
14. (A) Return to health for 60 days today; (B) Return to health for 111 days after 21 days.
15. (A) Return to health for 153 days today; (B) Return to health for 188 days after 92 days.
16. (A) Return to health for 108 days today; (B) Return to health for 133 days after 89 days.
17. (A) Return to health for 177 days today; (B) Return to health for 188 days after 141 days.
18. (A) Return to health for 53 days today; (B) Return to health for 77 days after 28 days.
19. (A) Return to health for 73 days today; (B) Return to health for 177 days after 14 days.
20. (A) Return to health for 62 days today; (B) Return to health for 66 days after 161 days.
21. (A) Return to health for 75 days today; (B) Return to health for 111 days after 30 days.
22. (A) Return to health for 55 days today; (B) Return to health for 77 days after 80 days.
23. (A) Return to health for 91 days today; (B) Return to health for 166 days after 20 days.
24. (A) Return to health for 119 days today; (B) Return to health for 133 days after 118 days.
25. (A) Return to health for 119 days today; (B) Return to health for 177 days after 30 days.
26. (A) Return to health for 49 days today; (B) Return to health for 55 days after 122 days.
27. (A) Return to health for 44 days today; (B) Return to health for 122 days after 7 days.

### Part 5. Numerical Rating Scale

Please rate the pain (0 = not at all painful, 10 = extremely painful).

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0	1	2	3	4	5	6	7	8	9	10
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**Part 6. Emotion Self-assessment Questionnaire**

Please rate your current emotional state (1 = not at all, 9 = extremely). Tick the number “√” (Rate one or more of the emotions you’re having right now).

Emotion type	1	2	3	4	5	6	7	8	9
Joy									
Anger									
Peace									
Anxiety									
Pain									
Sadness									

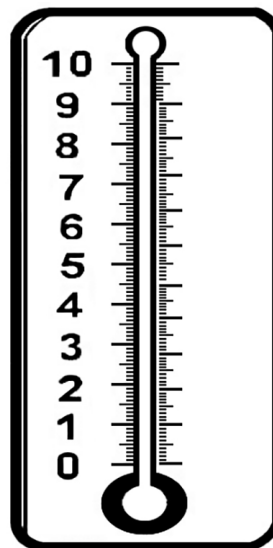
**Part 7. Distress Thermometer**

Please select the single number that best represents your psychological pain intensity, 0 representing “not at all painful ” and 10 representing “extremely painful”.

Extremely Painful

Moderately Painful

Not at All Painful



**Research results**

**Part 1. Results of Health Intertemporal Choice**

In Experiment 1, compared with the participants in non-pain group ( $M = 63\%$ ), those in pain ( $M = 38\%$ ) were less impatient for choices involving health outcomes ( $F(1,58) = 32.23, p < .001$ ). In Experiment 2, compared with the participants in non-pain group ( $M = 51\%$ ), those in pain ( $M = 35\%$ ) were less impatient for choices involving health outcomes ( $F(1,58) = 5.00, p = .029$ ). In Experiment 3, no significant difference was noted in the proportion of impatient choices between the pain group ( $M = 38\%$ ) and the non-pain group ( $M = 39\%$ ) in the health task ( $F(1,66) = 0.028, p = .868$ ).

The effect of pain on intertemporal choice in health domain is inconsistent with that in other two domains. In the opinion of reviewers, this inconsistency likely resulted from difficult that participants had with this scenario. Specifically, in the short-term condition, participants were asked to imagine that an unspecified bad health state got better for a relatively short time and then got bad again. Although the items were based on those of Chapman & Elstein (1995), those original items had a much longer introduction, explaining the illness and its symptoms and asking participants to imagine “that this state of health will continue unchanged for the rest of your life.” Without this extended explanation, our participants may have found it difficult to assume that the baseline was a chronic health condition. They may have assumed that, once they got relief, they could continue to get relief, or would get permanent relief again at some future date.

## Part 2. Results of Emotion

The emotion reported by the participants are shown in Tables A1, A2 and A3. The questionnaire did not ask participants to rate all emotions but rather to select some for rating, using the scale shown above in Part 5. The non-selected emotions were assigned a rating of “1” (the lowest) for analysis of the data. Although this was our best guess, it might have induced additional error if the selected emotions were chosen for some other reason aside from being the strongest. Yet we would lose too many observations if we simply treated the omitted emotions as missing data. Moreover, the selected emotions might have been the ones that participants in the pain condition thought were most relevant to the experimental manipulation. If this happened, it would show a stronger effect of the manipulation than would otherwise be found. Thus, on the recommendation of a reviewer, we include these results here.

TABLE A1. The reported emotion in both the pain and the non-pain group in Experiment 1.

Emotion type	Stimulus type	M	SD	t	P
Joy	Pain	1	0	-3.52	<.001
	Non-pain	1.4	0.62		
Anger	Pain	1	0		
	Non-pain	1	0		
Peace	Pain	1.37	0.96	-4.51	0.001
	Non-pain	3.2	2.01		
Anxiety	Pain	3.8	1.83	8.39	<.001
	Non-pain	1	0		
Pain	Pain	3.07	1.78	6.36	<.001
	Non-pain	1	0		
Sadness	Pain	1	0		
	Non-pain	1	0		

Note: The emotion of the non-pain group is the baseline emotion before the experimental manipulation, while the emotion of the pain group is the pain-derived emotion.

TABLE A2. The reported emotion in both the pain and the non-pain group in Experiment 2.

Emotion type	Stimulus type	M	SD	t	P
Joy	Pain	1	0	-3.34	<.001
	Non-pain	1.33	0.55		
Anger	Pain	1	0		
	Non-pain	1	0		
Peace	Pain	1.37	1.07	-3.65	0.006
	Non-pain	2.77	1.81		
Anxiety	Pain	3.93	1.96	8.18	<.001
	Non-pain	1	0		
Pain	Pain	3.07	1.95	5.82	<.001
	Non-pain	1	0		
Sadness	Pain	1	0		
	Non-pain	1	0		

Note: The emotion of the non-pain group is the baseline emotion before the experimental manipulation, while the emotion of the pain group is the pain-derived emotion.

TABLE A3. The reported emotion in both the pain and the non-pain group in Experiment 3.

Emotion type	Stimulus type	M	SD	t	P
Joy	Pain	1.06	0.34	-2.72	<.001
	Non-pain	1.38	0.6		
Anger	Pain	1.09	0.51	1	0.043
	Non-pain	1	0		
Peace	Pain	1.18	1.03	-7.1	<.001
	Non-pain	3.79	1.89		
Anxiety	Pain	5.06	1.79	13.21	<.001
	Non-pain	1	0		
Pain	Pain	5.29	1	25.02	<.001
	Non-pain	1	0		
Sadness	Pain	3.68	2.41	6.48	<.001
	Non-pain	1	0		

Note: The emotion of the non-pain group is the baseline emotion before the experimental manipulation, while the emotion of the pain group is the pain-derived emotion.