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## RESEARCH ARTICLE

# Effect of Brief Mindfulness Intervention on Tolerance and Distress of Pain Induced by Cold-Pressor Task

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### Abstract

A number of studies have demonstrated that short-term meditation intervention can lead to greater tolerance and lower pain or distress ratings of experimentally induced pain. However, few attempts have been made to examine the effects of short-term mindfulness-based intervention on the tolerance and distress of pain, when delivered in a therapist-free form. The present research explored the effect of brief mindfulness intervention using pre-recorded instruction on pain experimentally induced by the cold-pressor task. The effects of the mindfulness strategy, the distraction strategy and spontaneous strategy, all through the instructions of pre-recorded voices, were compared. The subjects were drawn from healthy college students and randomly assigned to the aforementioned three groups. Our results showed that compared with using spontaneous strategies, the mindfulness intervention significantly improved the participants' pain tolerance and reduced their immersion distress. The distraction strategy also significantly improved the participants' pain tolerance. However, it did not have a significant effect on the participants' level of distress during the immersion period. Our results suggest that brief mindfulness intervention without a therapist's personal involvement is capable of helping people cope with pain induced by the cold-pressor task. Copyright © 2012 John Wiley & Sons, Ltd.

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### Keywords

mindfulness; cold-pressor task; experimental pain; distraction

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## Introduction

A volume of research work has demonstrated that meditation training, such as mindfulness-based stress reduction and Acceptance and Commitment Therapy, can help attenuate pain symptoms, which is a major stressful source for human beings, and increase psychological well-being (Brown & Ryan, 2003; McCracken, Gauntlett-Gilbert, & Vowles, 2007). This effect is not just psychological. It has been evidenced that persistent meditation practice can modulate pain-related neural mechanisms (Brown & Jones, 2010; Orme-Johnson, Schneider, Son, Nidich, & Cho, 2006; Zeidan *et al.*, 2011). However, existing training programmes usually require trained professionals to lead the sessions and hundreds of hours of practice to produce an enduring effect (Brown & Ryan, 2003; Kabat-Zinn, 1982), which limit the impact of these programmes because many patients may either have no access to experienced guides or do not have enough time to fully participate in the training programmes. A therapist-free short-term intervention would be ideal for these patients.

A number of studies have shown that short-term meditation intervention can also lead to more tolerance, lower pain or distress ratings of experimentally induced pain, compared with control groups (e.g. Masedo & Esteve, 2007; Zeidan, Gordon, Merchant, & Goolkasian, 2010). For example, in Zeidan *et al.* (2010)'s study, participants' numerical ratings of pain to electrical stimulation significantly decreased after a 3-day mindfulness meditation training. Pain sensitivity, measured by change in stimulus intensity thresholds, also decreased after mindfulness meditation training. In their study, math distraction task reduced high pain ratings, although no reduction in pain sensitivity was found in these participants. However, these studies involved direct interaction between trained professionals and participants.

As our knowledge, the only exception is in McMullena *et al.* (2008)'s study, participants were guided to learn an acceptance-based strategy using a series of video clips. Their results showed that the subjects in acceptance group were more tolerant to electric shocks in the post-intervention condition than in the baseline condition. However, the study failed to observe any significant effect of the

intervention on self-reported pain or distress ratings. We suspect this is due to the fact that disconnection between thoughts and actions as the core technique of the acceptance strategy was used in that study. The intervention did not give enough emphasis on other therapeutic factors of mindfulness such as objectively observing and re-perceiving one's inner experiences, which is considered as core component of mindfulness meditation-based interventions (McCracken *et al.*, 2007; Shapiro, Carlson, & Astin, 2006).

To our knowledge, no attempt has been made to examine the effects of mindfulness-based intervention delivered in a therapist-free form to date. As we have discussed before, the success of such interventions would benefit a great number of patients. Therefore, we conducted this study to further investigate the effect of pain management using therapist-free mindfulness interventions.

Our study examined the effects of three types of coping strategies: (1) mindfulness intervention, which included psycho-education and exercises of the accepting attitude and objectively observing and re-perceiving one's inner-experiences (such as sensation, thoughts and feelings); (2) distraction intervention, which included psycho-education and exercise of distracting attention from the inner experience; (3) a spontaneous condition in which the participants rested and listened to light music. The instructions for each of the interventions were given using pre-recorded audios and lasted for 15 minutes. We hypothesized that even when instructed by pre-recorded audios instead of a therapist, the mindfulness strategy would still work better for increasing the subjects pain tolerance and reducing their experiences of pain intensity and pain related distress when compared with the other two strategies.

## Method

### Participants

Eighty-six undergraduates participated in the experiment. They were compensated by either course credits (50 students) or 15 RMB (36 students). Informed consent was obtained from each subject prior to the data collection process. The subjects were aware of the experimental procedure and their right to withdraw from the study at any time without penalty.

The participants then went through a screening procedure. They were excluded from the study if any of the following medical conditions were present: an existing pain condition, history of heart disease, high blood pressure or Reynaud's disease. In addition, those who had meditation experience were also excluded. Finally, in order to increase the power of the experimental intervention, we followed the convention and excluded the participants who were able to keep their hands in ice-water for 5 minutes or longer during their first cold-pressor task (Hayes *et al.*, 1999; Masedo & Esteve, 2007).

In total, 26 subjects were excluded from the study. Six of them were excluded because of their prior meditation experience and 20 were because of their ability to keep their hands in the ice-water for 5 minutes in their first cold-pressor task. Our final sample contained 60 female participants with the average age of 20.48 years ( $SD=1.47$ ). They were randomly divided into three groups with 20 subjects in each group. This sample size is similar to the sample sizes in McMullena *et al.* (2008) and Keogh *et al.* (2005)'s studies. Figure 1 illustrates the overall procedure of our study. The means and the standard deviations of the ages of subjects in each group were the following: mindfulness condition, 20.85 years ( $SD=1.14$ ); distraction condition, 20.56 years ( $SD=1.10$ ); and spontaneous condition, 20.17 years ( $SD=1.65$ ).

### Cold-pressor task

The cold-pressor task has demonstrated good reliability and validity for pain induction (Edens and Gil, 1995). The cold-pressor apparatus consists of two plastic containers. One is filled with warm water at 36–37°C. The other is filled with cold water and ice. The ice is wrapped in a plastic tuck net that is fixed on the side of the container in order to prevent the subjects' hands from touching the ice directly. The cold water is constantly circulated by a pump to keep its temperature within the range of 4–6°C. During the cold-pressor task, a baseline temperature was administered by having the participants place their right hands into the warm water for 2 min and then move their hands into the cold water immediately. The participants were signalled by a bell sound to move their hands. The participants were asked to keep their hands in the cold water as long as they could and to terminate the immersion when they could not tolerate the pain any more (there was a limit of 5 minutes for maximum

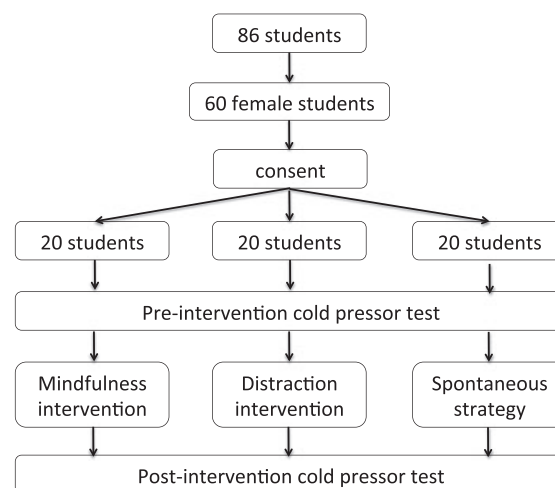


Figure 1 Procedure of the study

tolerance time, but the participants were not informed of this limit.)

During the cold-pressor task, the following measures were taken:

**Pain tolerance:** The tolerance time is the length of time that the subject's right hand was kept in the cold water. The seconds of immersion were recorded using a digital stopwatch.

**Pain ratings:** Subjective pain was assessed by a Likert scale (displayed in front of the subject during the cold-pressor task) with the endpoints (0) indicating 'no pain' and (10) indicating 'the worst pain'. Participants were asked to report their ratings verbally as soon as they withdrew their hands from the cold water.

**Distress ratings:** Subjective distress was assessed by a Likert scale (displayed in front of the subject during the cold-pressor task) with the endpoints (0) indicating 'no distress' and (10) indicating 'the worst distress'. Participants were asked to report their ratings as soon as they withdrew their hands from the cold water after pain rating.

## Intervention

In this study, we applied three types of interventions: mindfulness, distraction and spontaneous strategies. The instructions for both the mindfulness and the distraction conditions were given by recorded voices. For the spontaneous strategies group, no instruction was given. Instead, we played light music for the participants. The interventions for each of the groups lasted 15 minutes.

At the beginning of the interventions, the participants were provided with the rationale for the study. All three groups were informed that the aim of the study was to help people who are suffering from chronic pain and therefore it is important that they treat the cold-pressor task seriously. At the end of the recordings, the subjects in the mindfulness and the distraction groups were instructed to employ the strategies they learned from the recordings during their post-intervention cold-pressor task.

## Mindfulness intervention

The followed 15-minutes instruction was designed by the authors, who have 5 years mindfulness meditation experience.

The first part of the recording focused on introducing the idea of mindfulness: awareness and acceptance of the condition. The subjects were informed that accepting pain and pain-related negative thoughts and affections allows one to become more objective, which will in turn reduce the experience of pain distress and allow one to be free from the undesirable experiences.

After listening to the introduction part of the recording, the subjects were asked to practice for 10 minutes

following the recorded instructions. The key points of the instructions are:

- Directing attention to the flow of breath.
- Being aware of the flow of breath, but not trying to control it.
- Accepting and observing sensations and feelings without avoiding or trying to control them.
- When experiencing a feeling of discomfort and having a thought such as 'It is unbearable for me' or 'I should do something to change the situation', please do not respond them immediately as a fact, but just try to notice these thoughts and observe them as a kind of inner experience from time to time.
- A metaphor of the relationship between weather phenomenon and the sky was provided to help the subjects understand how to accept and observe their inner experience. Weather can change frequently and unpredictably, but it will not affect the nature of the sky. Similarly, one can observe his/her own inner experiences without being affected.

## Distraction intervention

Before the present study, we conducted a pilot study to investigate the coping strategies used by subjects spontaneously when they were confronted with pain and distress. We found that most of the subjects who had a relatively longer period of pain tolerance tried to distract their attention from their current experience by creating a mental image of a happy or relaxing scene. On the basis of this finding, instead of being instructed to solve math problems which is a common strategy used in experimental psychological studies as a distraction, the participants in the distraction group were asked to direct their attention away from the pain and the negative emotions and thoughts by imagining a happy or relaxing scene. This is similar to the instructions used in McMullena *et al.* (2008)'s study.

The procedure of the intervention is as following: similar to the mindfulness condition, the first part of the recording focused on introducing the idea of distraction: turning one's attention away from the pain and pain-related thoughts and feelings and thinking of something happy or relaxing can help the person to tolerate the situation longer.

After the subjects finished listening to the introduction, they were asked to practice for 10 minutes following the recorded instructions. The key points of the instructions are:

- Directing attention to the flow of breath.
- Turning attention away from the sensations, feelings or thoughts by thinking about something happy or relaxing.
- When experiencing a feeling of discomfort and having a thought such as 'It is too unbearable for me' or 'I should do something to change the situation', try think about something happy or relaxing to distract your attention from these kinds of feelings and thoughts.

## Spontaneous strategies

The subjects in this group were instructed by the recording to rest and listen to light music for 15 min.

## Procedure

After signing informed consent forms, the participants were informed of the procedure of the cold-pressor task through a set of PowerPoint slides. The participants completed their first cold-pressor task by following instructions displayed in front of them using a computer in Experiment Room 1. Experimenter 1 was present in the room and would give additional explanations about the process if requested prior to the task. Then the participants went to Experiment Room 2 to receive their interventions. We put each three consequent participants into a group based on their sign-up time. When the first participant of a group entered Experiment Room 2, Experimenter 2 allocated him/her to one of the three conditions (the mindfulness group, the distraction group or the spontaneous strategies group) by throwing dice. The second participant then was assigned to one of the other two conditions using the same method, and the third participant was assigned to the last condition. After receiving their respective interventions, the participants went back to Experiment Room 1 and completed the second cold-pressor task. The cold-pressor task and the intervention were both conducted individually. The interval between the two cold-pressor tests was 20 minutes for each participant, which includes the 15 minutes interventions.

In the present study, the participants did not know which strategy was preferred by the researchers, and the experimenter who carried out the cold-pressor task did not know which type of intervention the participants received.

## Results

In this study, the independent variable is the type of intervention the subjects received, and the dependent variables are pain tolerance, pain ratings and distress ratings. Prior to data analysis, the data of four subjects were removed as outliers because one or more of their observed data values fall outside of the 95% confidence interval of the corresponding variables.

### Pre-intervention group differences

The means and standard deviations (SD) of all the recorded variables are listed in Table I. One-way analyses of variance (ANOVAs) confirmed that the three groups did not differ significantly in any of the three dependent variables (all  $p$ 's > .1) at their pre-intervention tests.

### Pain tolerance

Table I lists the means and standard deviations of the duration of immersion for all three groups. The mixed repeated ANOVA, with the time of the test--pre-intervention versus post-intervention--as the within

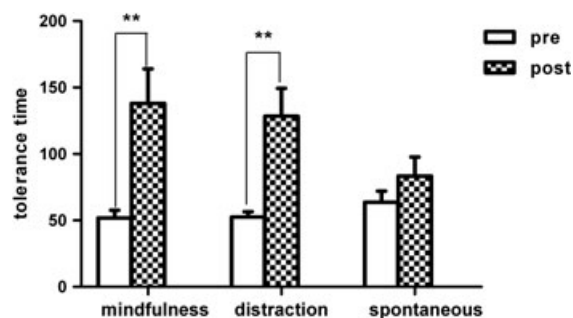
**Table I.** Descriptive statistics for study variables

	Pain tolerance		Pain ratings		Distress ratings	
	Pre	Post	Pre	Post	Pre	Post
Mindfulness						
Mean	51.95	138.05	6.70	6.10	4.50	3.00
SD	25.87	116.55	1.63	1.77	2.24	1.86
Distraction						
Mean	52.61	128.39	6.67	6.44	4.44	3.28
SD	17.10	89.32	1.68	1.54	2.50	2.11
Spontaneous						
Mean	63.72	83.39	6.72	7.28	3.67	4.17
SD	35.71	60.77	1.41	1.90	2.64	2.73

group factor and three intervention group as between group factor, yielded a significant main effect for test time ( $F(2, 53) = 32, p < .01$ ) and a significant interaction effect ( $F(2, 53) = 3.70, p < .05$ ). Because of the significant interaction effect, post hoc paired-sample  $t$ -tests between the pre-tests and the post-tests were conducted for each of the three intervention groups. The results showed that the tolerance time increased significantly in the mindfulness group ( $t(19) = -3.32, p < 0.01$ ) and the distraction group ( $t(17) = -3.91, p < 0.01$ ). There was no significant difference in the spontaneous group ( $t(17) = -1.94, p = 0.07$ ) (see Figure 2).

### Pain ratings and distress ratings

The means and the standard deviations for the pain and distress ratings from all three groups are presented in Table I. The mixed repeated ANOVA test on pain ratings, with the time of the tests: pre-intervention versus post-intervention as the within group factor and the intervention type as the between group factor, found neither significant main effect nor interaction effect. The mixed repeated ANOVA test on distress ratings, using the same within and between group factors as the previous tests generated a significant main effect for test time ( $F(2, 53) = 5.76, p < .05$ ) and a significant interaction effect between the intervention groups and the time of testing ( $F(2, 53) = 4.20, p < .05$ ). Post hoc paired-sample  $T$ -tests indicated that



**Figure 2** Pain tolerance of pre and post intervention



the difference between the ratings in the pre-test and the post-test was significant in the mindfulness group ( $t(19) = 2.27, p < 0.05$ ), but not in either the distraction group ( $t(17) = 1.8, p = 0.09$ ) nor the spontaneous group ( $t(17) = -1.77, p = 0.10$ ) (see Figure 3 for details).

## Discussion

The present research explored the effect of a brief director-free mindfulness intervention (15 minutes) on people's ability to manage pain during the cold-pressor task, using healthy female college students as subjects. We compared the effects of the mindfulness intervention with those of the distraction intervention and spontaneous coping strategies. Consistent with our hypotheses, the mindfulness group showed a significant improvement in pain tolerance time and the spontaneous group had no significant change. This finding agrees with the results from Masedo and Esteve (2007), which found that the subjects in the acceptance/mindfulness group demonstrated greater tolerance of pain compared with the subjects in the spontaneous groups.

Moreover, significant decrease in pain-related distress was found in the mindfulness group in the present study. The study of McMullena *et al.* (2008) failed to find any changes in self-reported distress in the acceptance group via employing video-based interventions. This result confirms our hypothesis that using the acceptance and objective observation strategies together can generate more positive results than using the acceptance strategy alone. Acceptance and objective observation are considered core components of mindfulness (McCracken *et al.*, 2007; Shapiro *et al.*, 2006). It is believed that one of the analgesic mechanisms in mindfulness that is associated with the ability of regulating a person's affective reaction to pain is through refocusing attention: turning it away from the catastrophic thoughts and onto the present-moment experience with an acceptance attitude (Bishop *et al.*, 2004; Brown and Ryan, 2003). In addition, if the participants face and observe the pain, they could gradually learn that the pain is in fact not so scary and uncontrollable.

The present study failed to demonstrate a main effect on pain ratings by the intervention type. This is

contradictory to Masedo and Esteve (2007)'s study, which found that the acceptance strategy produced lower subjective pain and distress ratings than the suppression and spontaneous coping strategies. One possible explanation for our results is that the interventions in Masedo and Esteve (2007)'s experiments involved direct social interaction with a researcher-therapist. A therapist can assess the progress of the intervention and make adjustments accordingly, which can help the participants to learn the strategies more effectively. Consistent with this explanation, McMullena *et al.*, (2008)'s research which employed video-based interventions also failed to find difference in the participants' pain and distress ratings between their experimental groups.

The present study hypothesized that the mindfulness strategy can increase people's pain tolerance and decrease their experiences of pain intensity more effectively than the distraction strategy. However, we did not find a significant difference between these two groups in terms of the subjects' pain tolerance time and pain intensity. In fact, distraction group showed a significant improvement in pain tolerance time in the present study. This result was similar to Zeidan *et al.* (2010)'s study, in which the participants' numerical ratings of pain by electrical stimulation significantly decreased in the mindfulness group and the math distraction group. Moreover, the distraction strategy was also effective for chronic pain patients during the cold-pressor task (Nouwen *et al.*, 2006). One possible reason is that distraction and focused strategies might have different effects for chronic pain and short-term pain. Distraction might be more effective for shorter periods, whereas mindfulness might be more effective for longer pain episodes (Nouwen *et al.*, 2006). Numerous researches have already demonstrated that mindfulness-based training can help attenuate symptoms and distress in patients with chronic pain (Brown and Jones, 2010). Therefore, we believe that the mindfulness strategy can benefit a larger audience and therefore deserves more attention in future studies.

The current study has several limitations. Firstly, all of the subjects are female after the participants' exclusion process, owing to their greater availability given the participant subject pool. Although this study was not designed to explore the effect of gender differences, this fact limits our confidence in generating our results to the male population because an interaction effect between coping strategy and gender has been reported by Keogh *et al.* (2005). Secondly, in the present study, 23% of the subjects were removed because of their ability to hold on in the cold-press task for more than 5 minutes. This screening procedure was adapted from existing studies in the same area, i.e. Masedo and Esteve (2007) and Hayes *et al.* (1999) as a means to increase the power of the experimental intervention. However, this screening procedure limits our ability to generalize our results to that population. Thirdly, our interventions rely on verbal instructions, and minor differences exist between the recordings used in the mindfulness and

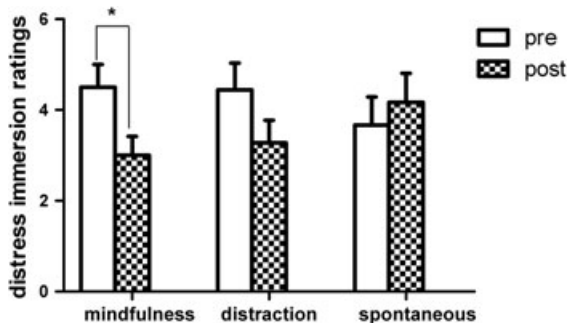


Figure 3 Distress ratings of pre and post intervention

the distraction groups, such as slightly different words choices. They may accidentally lead to the difference we found across groups. It is not possible to get rid of this effect totally. Therefore, caution should be heeded in generalizing the results.

Despite the aforementioned limitations, we believe that this study has many important theoretical and practical values. Firstly, this research demonstrates the possibility of developing effective mindfulness-based interventions using pre-recorded instructions, which allows the intervention to benefit a much wider audience compared to when human therapists are required for directing the intervention. Secondly, the significant analgesic effects of a short-term mindfulness intervention clearly reflect the superiority of the 'well targeted' features of the intervention. The effective brief intervention used in the present research contains psychological education about pain-related mindfulness principles and operational guidance for how to accept, objectively observe and re-perceive one's inner-experiences (feelings, emotions and thoughts). If future work can perform quantitative analysis about the effectiveness of each element in this cognitive-behavioural regulation, we believe it will become a significant step towards understanding the mechanisms of mindfulness-based therapy. Thirdly, our results provide additional insights into the benefits of the mindfulness strategy. The present findings are consistent with previous research which

demonstrated that acceptance in a mindful state can reduce pain-related distress more effectively than other control-based techniques. It is well established that unpleasant pain-related affective experiences often lead to avoidance behaviours, and then disability and social isolation, which further complicates the situation of the pain patients (Vlaeyen *et al.*, 1995; Vlaeyen and Linton, 2000). Therefore, the clinical implications of acceptance and awareness of the pain experience are important to prevent the development of avoidance behaviours and disability and consequently enhance the patients' mental well-being and the quality of their lives. We expect that our research will inspire future studies to examine the mechanisms for pain management using therapist-free mindfulness and acceptance-based therapies. Ultimately, this avenue of research will offer an opportunity for more patients to benefit from these promising therapies.

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## Conflict of Interest

The authors have declared that there is no conflict of interest.

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