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Turning pain into cues for goal-directed behavior: Implementation intentions reduce escape-avoidance behavior on a painful task.

Running title: implementation intentions and pain

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Abstract

Pain automatically elicits escape-avoidance behavior to avert bodily harm. In patients with chronic pain long-term escape-avoidance behavior may increase the risk of chronic disability. The aim of the presents study was to examine whether implementation intentions, reduce escape-avoidance behavior during painful tasks in healthy individuals. Implementation intentions are “if-then” self-statements associating situational cues with goal-directed behaviors.

Seventy healthy participants performed a painful finger pressing task, preceded by either implementation intention instructions with pain or a non-pain cue as a cue for goal directed behavior, or control instructions. Escape-avoidance behavior was operationalized as both task duration and response rate. Inhibitory control was measured using the Stop Signal Task.

The pain implementation intentions resulted in the highest task duration (p = .02), and thus less escape-avoidance behavior. Low inhibitory control was associated with shorter task duration (p = .03), and thus more escape-avoidance behavior. The non-pain implementation intentions resulted in the highest response rate, but only when inhibitory control was low (p = .04).

Implementation intentions referring to pain or non-pain reduce escape-avoidance behavior on a painful task. It is worthwhile to examine whether individuals in pain and with low inhibitory control benefit from interventions that incorporate implementation intentions.

Perspective

This study is the first to show that forming implementation intentions reduce escape-avoidance behavior during pain and foster non-pain goal pursuit. The use of implementation intentions is indicated to be an intervention that could be of use in dealing with pain, particularly when inhibitory control is low.

Keywords

Experimental pain; Goal pursuit; Implementation intentions; Inhibitory control; Escape-avoidance behavior

Introduction

Pain is a biologically hardwired signal of bodily threat automatically eliciting withdrawal responses,[14] such as avoiding a sensation that is expected to be painful and escaping from the continuation of a sensation that already is painful.[13] Escape-avoidance behavior protects the body from harm, but may be maladaptive when pain occurs without imminent harm. Escape-avoidance behavior results in failing to reach valued life goals and may instigate chronic pain and disability.[45] Current affective-motivational models postulate that escaping or avoiding pain is not solely explained by a primitive defensive threat system, but also by conflicting (non-pain) goals, such as finishing tasks satisfactorily.[12,25,44] For example, a person experiencing pain while writing a report may have both the goal to avoid pain and the conflicting non-pain goal to finish the report. Research has demonstrated non-pain goals to reduce escape-avoidance behavior during painful tasks in individuals with[23] and without chronic pain.[6,28,41]

An unresolved issue is how goal conflicts are solved between short-term escape-avoidance goals (i.e., pain reduction) and long-term non-pain goals (i.e., finishing the task). Individual differences in inhibitory control may be involved in the resolution of goal conflicts.[16,36] Inhibitory control is an effortful system acting control over an automatic approach-avoidance system to attain long-term task goals.[7,19] Low inhibitory control may lead to difficulty suppressing automatic escape-avoidance tendencies. Indeed, research has demonstrated that low inhibitory control predicted early termination of painful tasks[26,38,47] and was associated with chronic pain.[37] These findings suggest, that it is beneficial to develop interventions assisting inhibition of escape-avoidance tendencies during pain to enhance the attainment of task goals. This study examines this notion in a healthy sample. In future, such interventions can be trialed with patients with chronic pain who display low inhibitory control.

A well-known intervention improving goal attainment is forming implementation intentions by specifying when, where and how goals can be achieved.[20,21] Implementation intentions create an association between a goal-directed response Y and occasion X, through predetermined "if-then" propositions (e.g., to prevent snacking: If I sit down to watch television, then I eat an apple). This if-then connection improves the accessibility of the critical cue in memory, enhancing the detection of the cue.[1] Once the cue is detected, goal-directed behaviors are assumed to be automatically activated.[5] Research shows that implementation intentions facilitate the initiation of desired behaviors.[21] However, the reduction of escape-avoidance behavior during (non-harmful) painful tasks is more complicated as this requires the simultaneous activation of two processes: the suppression of an undesired response (e.g., task disengagement) and the substitution of this response with a desired one (e.g., task continuance).[3]

Implementation intentions have been shown successful in substituting maladaptive behaviors.[3,31] In this procedure, the neutral cue (when and where) in the "if"-component was replaced by a motivational cue (e.g., pain) that normally elites unwanted responses (e.g., avoidance). This way, motivational cues activate the desired responses (e.g., approach) having the potential to override habitual undesired responses. For example, "If I have pain, then I will continue exercising." Research outside the pain domain has demonstrated that implementation intentions associating motivational cues (e.g., feeling tempted) with desired responses (e.g., dieting) effectively inhibit unwanted behaviors (e.g., eating chocolate),[2,3,31] particularly in people with low inhibitory control.[31]

The aim of the present study is to examine whether implementation intentions reduce escape-avoidance behavior during painful tasks. Two implementation intentions – specifying a non-pain cue or pain as a cue for goal-directed behavior – are compared to goal intentions specifying the desired end-state only. It was hypothesized that implementation intentions, as

compared to mere goal intentions, would reduce escape-avoidance behavior during painful tasks. Moreover, these effects were expected to be most pronounced when inhibitory control was low.

Methods

Participants

The participants were recruited via advertisement at different faculties of the Utrecht University. The inclusion criterion was an age between 18-65 years. Exclusion criteria were: 1) chronic pain, 2) acute pain in the upper extremities, neck, or shoulder 3) insufficient knowledge of the Dutch language. Participants received €5 or course credits for their participation. The ethical committee of the faculty of Psychology and Neuroscience of Maastricht University approved the study, and the procedures followed were in accordance with the Helsinki Declaration of 2008. After participants provided written informed consent, they were randomized into three experimental goal conditions. Block randomization was used such that each condition consisted of an equal number of participants (n = 25).

Implementation intentions have been shown to affect behavior with a medium to large effect size,[2,32] and a medium interaction effect between implementation intentions and inhibitory control has been shown.[32] A total sample size of 68 is needed, to be able to test the effect of implementation intention manipulations and the interaction effects of medium effect size between the implementation intention conditions and response inhibition. Our main analysis involved analysis of covariance including five variables: goal condition (because this variable has three levels, it was entered as two dichotomized variables), the moderator response inhibition, and the interaction effect between goal condition and inhibitory control (two variables). We used the F-tests linear multiple regression, fixed model, R^2 increase in G*Power 3.1.9.2[17] to compute the sample size. To reach a power of β=.80 with α= .05 and a

medium effect size (f2 =.15), a total sample size of 68 was required to test the interaction effect between goal condition and response inhibition. Anticipating 10% missing values, we choose a sample size of 75.

Escape-avoidance behavior. Participants performed an adapted Martians task,[35] which is a painful open-ended finger pressing task.[8,29] Participants were instructed that the goal of this computer game was to shoot alien invaders from Mars by pressing a button. Invaders appeared on the screen one by one in rows of 10 aliens with a regular speed of 5 invaders per second. Once an alien appeared on the screen, the participant was instructed to shoot the alien by a button press. When the button press was given within 100 ms after the appearance of the alien, the alien was hit, and a picture of an explosion replaced the picture of the alien. When the participant missed the alien, its picture remained on the screen. Participants pressed the button and shot aliens with the index finger of their dominant hand while their wrist was attached to the table with a wristband to avoid extensive movements with their dominant arm. Participants were instructed that there was no right or wrong time to stop the Martians task. They decided for themselves when to end the task by pushing the stop-button.[29] Participants were instructed that those with the highest performance on the Martians task could win €20, to induce task motivation. Unknown to the participant, the maximal duration of the Martians task was 90 minutes. Participants could show escape-avoidance behavior during the task in two ways. Firstly, they could escape from an already painful sensation or avoid pain exacerbation by early task termination.[4,13] Secondly, they could avoid (intense) pain by responding less frequently on the appearance of a Martian (response rate).[4,10,41] Therefore, escape-avoidance behavior was operationalized as task duration and response rate per minute. A previous study showed a mean task duration of 2 -7 minutes, and a mean response rate of 205 – 248 responses per minute, depending on the experimental manipulation. Moreover, a

previous study demonstrated that this task resulted in painful sensations (mean pain score between 4 and 5 on a scale from 0-10) caused by repeated muscle movement in healthy individuals.[29]

Goal conditions. Before the start of the Martians task the implementation intentions were experimentally manipulated. There were three goal conditions: mere goal intention, non-pain implementation intention and pain implementation intention. Participants were instructed to set the goal intention "*to shoot down as many Martians as possible*", and to repeat this goal for themselves in their mind one time. Participants in the goal intention condition received no further instructions. Participants in the *non-pain* and pain implementation intention conditions received an additional instruction to create a specific plan to improve their performance. Participants in the non-pain implementation intention condition were instructed to create an implementation intention associating the appearance of the Martians with the goal-directed behavior: "*If the Martians appear on the screen I will follow my goal to shoot down as many Martians as possible*." Participants in the *pain* implementation intention condition were instructed to create an implementation intention associating pain with the goal-directed behavior: "*If I feel pain I will follow my goal to shoot down as many Martians as possible*." After reading the implementation intention participants were instructed to retype the implementation intention on the computer. Next, they were instructed to repeat and visualize the plan in their mind a number of times for 60 seconds, and then to type the implementation intention once more on the computer.

Inhibitory control. Inhibitory control was measured with the Stop Signal Task (SST).[32] The task measures a persons' ability to inhibit prepotent responses. The task consisted of six blocks of 32 trials. There was a short break between the blocks. Before the six blocks

participants performed a practice block of 32 trials. Each block comprised two sorts of trials randomly intermixed: go-trials (75%) and stop-trials (25%). On go–trials participants were instructed to identify a go-stimulus by speeded right- or left-hand button presses (the X or O button). Each trial started with the presentation of a fixation cross which was replaced by the letter X or O randomly (the go-stimulus) after 500 ms. The go-stimulus remained on the screen for 1500 ms, regardless of response time. On the stop-trials, the onset of the go-signal was followed by an auditory stop-signal (a tone of 1000 HZ for 100 ms), instructing participants to withhold their response. A tracking procedure was used,[34] in which the interval between onset of the visual Go stimulus and onset of the auditory Stop stimulus was varied based on participants' task performance. When the participant inhibited successfully, the task was made more difficult by increasing the delay by 50 ms. Following an unsuccessful inhibition, the delay was decreased by 50 ms making the task easier. The delay at the start of the task was 250 ms. The intertrial interval was 1000 ms. Reaction times on go-trials of less than 150 ms were excluded. Two variables were calculated: the average reaction time (RT) and average stop delay in milliseconds (ms). The stop signal reaction time (SSRT), the main independent variable, was calculated by subtracting the mean stop delay from the mean RT.[29] Higher SSRTs indicate that participants need more time to inhibit a response, reflecting low response inhibition. The reliability and construct validity of the Stop Signal Task have shown to be satisfactorily.[11,23]

Pain. To check whether the task was painful and whether the three goal conditions did not differ on pain, two somewhat dissociable sensory and affective aspects of pain,[40] pain intensity and pain unpleasantness were assessed —without referring to a specific body part— before and after the Martians task. Before the task participants rated pain intensity and pain unpleasantness at the present moment. After the task participants were asked to indicate the

'*worst pain*' and the '*pain intensity and pain unpleasantness just before the end of the task*' retrospectively.[24,43] Ratings were made on an 11-point Likert scale ranging from 0 (*no pain at all*) to 10 (*the most intense pain imaginable*) for pain intensity and from 0 (*not unpleasant at all*) to 10 (*the most unpleasant pain imaginable*) for pain unpleasantness.[15,40] The construct validity of the items has shown to be satisfactorily.[24,40] An average pain intensity score was calculated of the worst pain ratings and the pain ratings just before the end of the task. The internal consistency of these two items was satisfactorily in the present study (Cronbach's alpha = .71).

Perceived experimenter demand. Demand characteristics could unduly influence the results. To check potential differences in demand characteristics between the three goal conditions, three questions were administered after the Martians task: "*To what extent were you serious about performing the task?*",[26] "*To what extent did you assume that the experimenter expected you to persist in the task?*", and "*To what extent did the experimenter convince you to try to persist in the task as long as possible?*" [5] Ratings were given on an 11-point Likert scale ranging from 0 (*not at all*) to 10 (*very much*).

Motivation. To check the possibility that the effects of implementation intentions on escape-avoidance behavior could be explained by differences in task motivation[6,31] the following questions were administered: "*How important was it for you to perform well on the Martians task?*" and "*How important was it for you to persist doing the task?*" The questions were derived from previous research[6,25,31] and adapted to the present experimental task. Previous research demonstrated the construct validity of these questions.[18, 22] Ratings were made on an 11-point Likert scale ranging from 0 (*not at all*) to 10 (*very much*). An average motivation

score was calculated of the two items. The internal consistency of the two items was good in the present study (Cronbach's alpha = .87).

Procedure

Participants were told that the study was about the role of task motivation on painful task performance. After signing informed consent, participants completed biographical questions and baseline pain intensity and pain unpleasantness ratings on the computer. Next, they completed the Stop Signal Task on the computer. Subsequently, participants performed the finger-pressing task that was preceded by the goal intention instruction and implementation intention instructions. Participants rated their pain intensity and pain unpleasantness at the end of the task retrospectively, as well as questions about their motivation and the perceived experimenter demand. To determine whether participants were unaware of the hypotheses of the experiment, an open-ended question was administered asking about the goal of the experiment. All participants were debriefed about the design and purpose of the study and received an incentive (money or course credits) immediately after the experiment.

Statistics

To establish whether the three experimental groups did not differ on baseline characteristics and perceived experimenter demand an analysis of variances or chi-square difference test was performed with goal condition as between-subjects factor (goal intention, non-pain implementation intention versus pain implementation intention) and the following dependent variables: age, gender, response inhibition and experimenter demand.

Next, it was established whether possible effects of goal condition on task duration and response rate could be explained by differences in task motivation or pain intensity and pain unpleasantness. For task motivation analysis of covariance (ANCOVA) was performed with goal condition as between-subjects factor, response inhibition as centered covariate, and

task motivation as the dependent variable. For pain intensity and pain unpleasantness, a repeated measures ANCOVA was performed with goal condition as the between-subjects factor, response inhibition as centered covariate, and time (before versus after the task) as within-subjects factor.

Subsequently, to test the main hypotheses of the experiment, ANCOVA's were performed with goal condition as between-subjects factor, response inhibition as centered covariate, and task duration and responses rate as the dependent variables. If the effect of goal condition was significant, posthoc pairwise comparisons were performed between the three conditions using simple contrasts. Moreover, for all analyses of covariance the assumption of homogeneity of regression was tested. That is, to test the assumption of linear relationships between the covariate (response inhibition) and the dependent variable, interactions of the centered covariate with the between-subjects factor were calculated. Non-significant effects ($p > .05$) were deleted from the model one by one, starting with the higher order interactions.

Results

Participants

A sample of 75 students from Utrecht University participated in the experiment (42 men, 33 women; $M_{age} = 20.71$, $SD = 2.09$ years). Excluded were: 2 participants from the non-pain implementation intention condition because of technical errors during data acquisition, 2 participants from the non-pain implementation intention condition because either their stop-signal reaction time score (SSRT = 368 ms) or their task duration (64.09 min) deviated more than 3 *SD* from the group mean (SSRT: $M = 212$, $SD = 45$ ms; Task duration: $M = 13.70$, $SD = 2.68$ min) and 1 participant from the pain implementation intention condition because his response rate (190 responses/min) was less than 3 *SD* of the group mean ($M = 281$, $SD = 27$

response/min). The final sample size consisted of 70 participants (37 men, 33 women; M_{age} = 20.56, *SD*= 1.91 years) with 25 participants in the goal intention condition, 21 participants in the non-pain implementation intention condition and 24 participants in the pain implementation intention condition. None of the participants indicated to be aware of the hypothesis of the experiment.

Randomization check and alternative explanations

In Table 1 the means and standard deviations are presented of gender, age, response inhibition, experimenter demand, task motivation and pain for the three different goal conditions. To establish whether randomization was successful it was examined whether or not the three experimental groups differed on baseline characteristics. At baseline, no significant differences were obtained between the three goal conditions on gender; χ^2 (70) = 4.44, p = .11, age; F (2, 67) = 0.23, p = .80, η_p^2< .01, and response inhibition; F (2, 67) = 0.58, p = .56, η_p^2= .02, indicating that randomization was successful.

Moreover, it was established whether the three experimental groups did not differ regarding experimenter demand, task motivation or pain to rule out alternative explanations. The three goal conditions did not differ on experimenter demand. That is, no significant differences emerged between the three goal conditions on being serious about performing the Martians task (F (2, 67) = 1.20, p = .31, η_p^2= .03), on the degree to which the participants assumed that the experimenter wanted them to continue the task as long as possible (F (2, 66) = 0.15, p = .86, η_p^2< .01), and on the degree to which the participants thought that the experimenter tried to convince them to continue as long as possible (F (2, 67) = 0.37, p = .70, η_p^2= .01).

Moreover, task motivation and pain did not differ between conditions. That is, neither significant main effects on task motivation were found for goal condition (F (2, 66) = 2.67, p

= .11, η_p^2= .06) or response inhibition nor for the interaction between response inhibition and goal condition (p > .05). It was found that the task was painful as pain intensity and pain unpleasantness were significantly higher after than before the task (respectively, F (1, 61) = 72.33, p < .001, η_p^2= .54, and F (1, 64) = 42.29, p < .001, η_p^2= .40). However, response inhibition and goal condition were not significantly related to the increase in pain intensity (respectively, F (1, 61) = 0.16, p = .69, η_p^2< .01, and F (2, 61) = 0.12, p = .89, η_p^2< .01) and pain unpleasantness (respectively, F (1, 64) = 0.04, p = .86, η_p^2< .01, and, F (1, 64) = 0.27, p = .77, η_p^2< .01). No other main and interaction effects were obtained of response inhibition, goal condition and time on pain intensity and pain unpleasantness (all ps > .05).

The two main dependent variables, task duration and response rate were significantly associated, r (70) = .30 , p = .01 (medium effect size), indicating that a higher response rate was associated with longer task duration. Note that in the subsequent main analysis of response rate it was not controlled for task duration and vice versa, as a similar pattern of results emerged with and without statistical control.

Insert Table 1

Insert Figure 1

Total task duration. To test the hypothesis that implementation intentions reduce escape-avoidance behavior, operationalized as higher task duration on a painful task, an ANCOVA was performed with goal condition as between-subjects factor, response inhibition as centered covariate, and task duration as the dependent variable. Figure 1 displays the means and standard errors of task duration. A main effect of goal condition with a moderate effect

size was found; F (2, 66) = 4.07, p = .02, η_p^2= .11. Simple contrasts demonstrated greater task duration in the pain implementation intention condition as compared to the non-pain implementation intention condition; t (44) = 2.28, p = .03, and the goal intention condition; t (48) = 2.60, p = .01. No significant difference was observed between the non-pain implementation intention condition and the goal intention condition; t (45) = 0.21, p = .84. Additionally, a main effect of response inhibition was obtained with a moderate effect size, indicating that less response inhibition was associated with shorter task duration; F (1, 66) = 5.10, p = .03, η_p^2= .07. No significant interaction effect was obtained between response inhibition and goal condition; F (2, 66) = 0.79, p = .46, η_p^2= .02. These findings indicate that the pain implementation intention condition was effective in increasing task duration independent of the level of inhibitory control.

Response rate. To test the hypothesis that implementation intentions reduce escape-avoidance behavior, operationalized as higher response rate on a painful task, an ANCOVA was performed with goal condition as between-subjects factor, response inhibition as centered covariate, and response rate as the dependent variable. A main effect of goal condition; F (1, 64) = 4.65, p = .01, η_p^2= .13, but no significant main effect of response inhibition was found; F (1, 64) = 0.22, p = .64, η_p^2< .01.The significant main effect of goal condition was superseded by an interaction between response inhibition and goal condition; F (2, 64) =3.50, p = .04, η_p^2= .10. Figure 2 depicts the number of responses per minute as a function of goal condition and the level of response inhibition. Posthoc simple slope analyses [38] testing the effect of goal condition on response rate/min for the participants with low (M +1SD) and high response inhibition (M -1SD) separately, demonstrated a goal condition effect for participants with low response inhibition; F (2, 64) = 7.39, p < .01, η_p^2= .19, but not for those with high response inhibition; F (2, 64) = 0.19, p = .83, η_p^2< .01. For participants with lower response

inhibition, a higher response rate/min was found in the non-pain implementation intention condition as compared to the goal intention condition, t (44) = 3.82, $p < .001$, and the pain implementation intention condition, t (43) = 2.74, $p < .01$. No significant difference was observed between the pain implementation intention and goal intention condition; t (47) = 1.08, $p = .28$. These findings indicate that the non-pain implementation intention condition was effective in increasing the response rate, particularly in those with lower inhibitory control. The pain implementation intention condition was not effective on this measure.

Insert Figure 2

Discussion

The present study showed that implementation intentions reduce escape-avoidance behavior on a painful task and foster the pursuit of non-pain goals. As expected, the implementation intention creating an association between a non-pain task event (the appearance of the Martian) and goal-directed behavior (continue with the task) facilitated response rate, particularly in individuals with lower levels of inhibitory control. Moreover as expected, the pain implementation intention, creating an association between pain and goal-directed behavior, resulted in the greatest task duration. A higher level of inhibitory control was associated with greater task duration, irrespective of goal condition. Note that the effects of implementation intentions and response inhibition on task duration and response rate were not explained by differences in task motivation and pain as the different goal conditions and response inhibition were unrelated to pain intensity, pain unpleasantness, and task motivation.

The finding that the non-pain implementation intention improved the response rate as compared to goal intentions only (at least in people with low inhibitory control), is in line with research demonstrating that implementation intentions facilitate the initiation of goal-directed behavior.[21,20,21] A supposed mechanism is that implementation intentions create an association between a critical cue (i.e. the Martians) and goal-directed behavior (i.e. shooting down aliens). This may improve the accessibility of the critical cue in memory, which enhances the detection of the cue.[1] Once the cue is detected, goal-directed behaviors are automatically activated.[5,46,47]

The finding that a motivational implementation intention, creating an association between pain and goal-directed behavior, effectively increased painful task duration, is in line with previous research outside the field of pain demonstrating that motivational cues that normally trigger unwanted behaviors can be used to substitute these undesirable behaviors with desirable, goal-directed, behaviors.[2,3,31] The present study adds to previous research by showing that implementation intentions are also applicable to painful situations in which the undesirable behavior is related to avoidance rather than approach goals. This implies that implementation intentions can be used to turn pain into a cue for goal-directed behavior.

The two implementation intentions affected the two response variables differently. The pain implementation intention increased total task duration but not response rate. Conversely, the non-pain implementation intention increased response rate but not task duration. Task duration can be considered a proxy of escape from an already painful sensation or avoidance of pain exacerbation.[4,13] Response rate may reflect avoidance of pain as participants could avoid (intense) pain by not responding.[4,10,41] The findings suggest that implementation intentions specifying pain as the critical cue for goal-directed behavior postponed a final escape from pain or avoidance of pain exacerbation (task duration) rather than reduced avoidance of pain (response rate). In contrast, the non-pain implementation

intention appeared to predominantly reduce avoidance of pain. These findings cautiously suggest that the fit between the type of implementation intention and type of avoidance-escape behavior should be considered when using implementation intentions to help reaching competing non-pain goals during painful tasks. Future research is required testing this hypothesis.

The finding that reduced inhibitory control was associated with shorter task duration is in line with previous research demonstrating that individuals with low inhibitory control withdrew their hand earlier from a cold pressor task,[26,38,48] suggesting that individuals with a stronger ability to inhibit prepotent responses are better able to inhibit escape-avoidance responses elicited by pain in the service of a competing task goal. The results of the present study partly support the conjecture that implementation intentions are particularly beneficial in individuals with low inhibitory control. That is, particularly the non-pain implementation intention resulted in an improved response rate in individuals with low inhibitory control but not in those with high inhibitory control. Apparently, people with low inhibitory control profit most from a simple, straightforward behavioral instruction. This finding corroborates previous research demonstrating that those with poor self-regulation benefit more from implementation intentions than those with high self-regulation.[31]

A possible adverse effect of the pain implementation intention is that it increases pain because it facilitates the accessibility of pain-related information and attention towards pain. However, research testing that attention to pain-related information predicts higher pain intensity is limited and contradictory.[42] Moreover in the present study, no evidence was found that the implementation intentions influenced pain, as no differences in pain intensity and pain unpleasantness were observed between the three goal conditions.

The implementation intentions in the present study were created such that they specifically facilitated performance on a particular task. It is unknown to what degree these

implementation intentions also generalize to other behaviors outside the research lab. Future research that includes painful daily life activities will be helpful in establishing the generalizability of our results.

Another issue pertains to the label 'non-pain implementation intention' used in the present study. This label was used as an association was created between an initially non-painful task cue (the appearance of a Martian) and goal-directed behavior. However, it is possible that at the end of the task the Martian became a conditioned stimulus predicting pain. Thus, non-pain implementation intentions may become pain-related as an association is created between a cue predicting pain and goal-directed behavior.

A limitation with respect to power is that our analyses were not able to find significance with smaller than medium effect sizes. A limitation with respect to external validity is that only students without chronic pain were included. In this sense, this study is a proof-of-principle study motivating to examine the effects of implementation intentions in populations with chronic pain. It has been shown that an intervention including the formation of implementation intentions, besides cognitive behavior interventions and mental contrasting, improved the physical capacity in patients with chronic back pain.[9] Although it is impossible to separate the effect of the implementation intentions from the other interventions in that study, the findings tentatively suggest that implementation intentions may also be helpful in restoring physical function in patients with chronic pain. To bridge the gap between goal intentions and actions, implementation intentions could be useful, but future research is required to establish whether implementation intentions, as a stand-alone strategy, are beneficial in patients with chronic pain.[30]

Previous research on statements associating situational cues with goal-directed behaviors (implementation intentions), was mainly aimed at reducing approach behavior towards rewarding stimuli, such as decreasing unhealthy food intake.[3,20,21,31] In contrast, our

study is unique in using implementation intentions to reduce avoidance behavior away from punishing (i.e., painful) stimuli or to reduce escape from these stimuli. The present study was the first to show that creating associations between non-pain events or pain and goal-directed behaviors effectively improves task duration and response rate during a painful task. The results indicate that it is worthwhile to examine —particularly in individuals with chronic pain and reduced inhibitory control— whether a relatively brief and easy to apply cognitive-behavioral intervention based on the formation of implementation intentions, reduces escape-avoidance behavior and fosters the pursuit of non-pain goals.

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1 Figure Caption

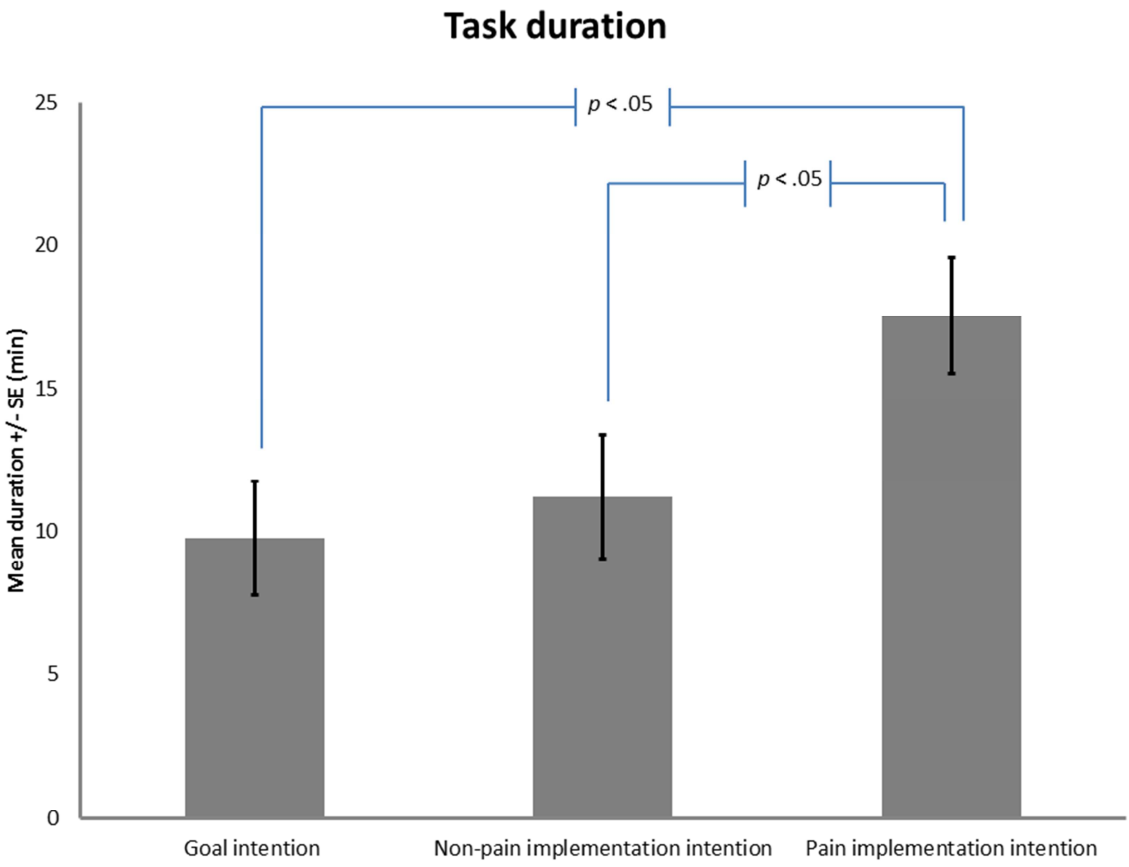
2 Figure 1. *Mean task duration (minutes) and standard errors in the three goal conditions.*

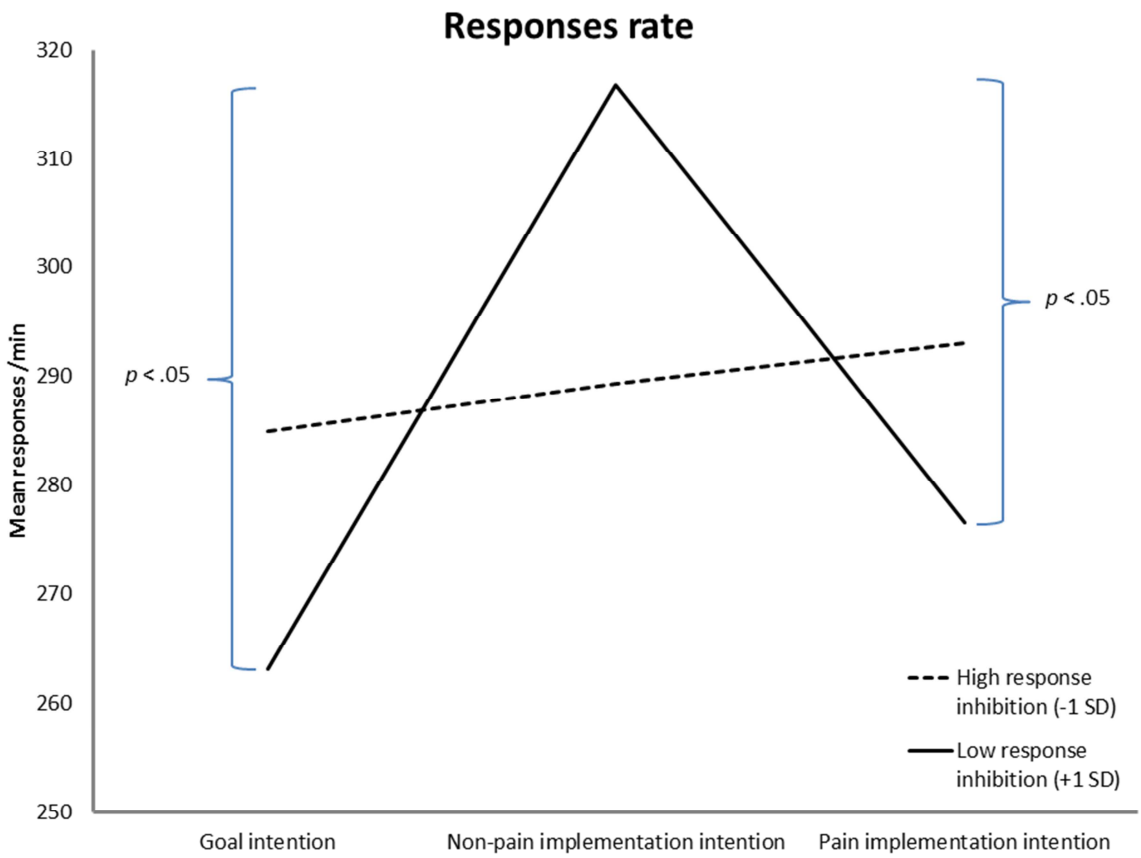
3 Figure 2. *Mean response rate (per minute) in the three goal conditions for participant with*
4 *high and low response inhibition. Note*. Low and high response inhibition were indicated by
5 high (+ 1 *SD*) and low (- 1 *SD*) scores on the Stop signal task, respectively.

Table 1. Characteristics of the participants in the three goal conditions

	Goal intention	Non-pain implementation intention	Pain implementation intention
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Gender (*n* m/f)	16/9	8/13	9/15
Age	20.41 (1.81)	20.74 (1.91)	20.62 (2.16)
Response inhibition (SSRT in ms)	222 (52)	210 (44)	218 (48)
Experimenter demand			
Seriousness	5.55 (2.30)	6.89 (2.05)	6.62 (2.27)
"The experimenter wanted me to continue as long as possible"	6.27 (2.69)	6.68 (2.81)	6.29 (3.13)
"The experimenter convinced me to continue as long as possible"	4.36 (2.74)	5.11 (3.70)	5.00 (3.18)
Task motivation	6.46 (2.23)	7.54 (1.78)	7.35 (1.59)
Pain intensity baseline	1.64 (0.85)	1.43 (0.68)	1.44 (0.60)
Pain intensity after task	4.20 (2.62)	3.71 (2.27)	4.11 (2.21)
Pain unpleasantness baseline	2.13 (1.52)	1.43 (0.68)	1.79 (1.25)
Pain unpleasantness after task	4.09 (2.63)	3.86 (3.15)	4.38 (2.79)

Note. SSRT, Stop signal reaction time, a higher SSRT reflects less response inhibition.





Highlights points

- Implementation intentions associate situational cues with goal-directed behavior.
- Escape-avoidance behavior reduces when goal-directed behavior is cued by pain.
- Inhibitory control is associated with less escape-avoidance behavior during pain.
- Implementation intentions reduce escape or avoidance when inhibitory control is low.
- Implementation intentions may help patients with pain and low inhibitory control.