# PAIN-AVOIDANCE VERSUS REWARD-SEEKING: AN EXPERIMENTAL INVESTIGATION

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**Abstract**

According to fear-avoidance models, a catastrophic interpretation of a painful experience may give rise to pain-related fear and avoidance, leading to the development and maintenance of chronic pain problems in the long term. However, little is known about how exactly motivation and goal prioritization play a role in the development of pain-related fear. The present study investigates these processes in healthy volunteers using an experimental context with multiple, *competing* goals. In a differential human fear conditioning paradigm, 57 participants performed joystick movements. In the control condition, one movement (conditioned stimulus; CS+) was followed by a painful electrocutaneous unconditioned stimulus (pain-US) in 50% of the trials, whereas another movement (non-reinforced conditioned stimulus; CS-) was not. In the experimental condition, a reward in the form of lottery tickets (reward-US) accompanied the presentation of the pain-US. Participants were classified in three groups, as a function of the goal they reported to be the most important: (1) *pain-avoidance*, (2) *reward-seeking*, and (3) both goals being *equally important*. Results indicated that neither the reward co-occurring with pain, nor the prioritized goal modulated pain-related fear. However, during subsequent choice trials, participants selected the painful movement more often when the reward was presented compared to the context in which the reward was absent. The latter effect was dependent on goal prioritization, with more frequent selections in the *reward-seeking* group, and the least selections in the *pain-avoidance* group. Taken together, these results underscore the importance of competing goals and goal prioritization in the attenuation of avoidance behavior.

## 1. Introduction

In fear-avoidance models, it is postulated that pain-related fear may lead to the development of chronic pain problems [22,49]. Even though there is extensive evidence on the role of pain-related fear in the understanding and management of chronic pain problems [27,54], some authors have argued to increase the explanatory power of fear-avoidance models by taking into account a motivational perspective [7,44,50,51]. Patients with chronic pain not only aim to control pain and avoid bodily harm, but often want to pursue other life goals as well [2,14,18,35,44,48]. One of the consequences of pursuing multiple goals, is that the pursuit of one goal can facilitate and/or interfere with the pursuit of other goals [3]. Being confronted with two competing goals, an individual has to make the−often difficult−choice which goal to pursue, whilst halting or even disengaging from the pursuit of the other goal [3,8,16,17,37].

A motivational account may provide further insights in the processes identified by fear-avoidance models. Patients who consider their life goals as more important than pain avoidance, might be more inclined to expose themselves to painful events when these facilitate reaching these life goals. However, when patients prioritize the goal to avoid pain at the expense of the attainment of other life goals, disability and increased suffering may be the result [12,42]. Only recently, research has begun to investigate the impact of competing goals on pain-related fear and avoidance behavior. Using the voluntary joystick movement (VJM) paradigm, which is a well-established human fear conditioning paradigm [29–31], Claes and colleagues found that a concurrent reward reduced avoidance behavior while pain-related fear remained unaltered [6]. However, this study did not investigate the role of individual differences in goal prioritization. It may very well be that the effects of goal competition differ as a function of which type of goal participants prefer, that is, preferring to avoid pain, or to earn a reward. Therefore, a replication and extension of this finding is warranted.

The current experiment was designed to further investigate the impact of goal competition on pain-related fear and avoidance behavior, and to examine how goal preferences moderate these effects. To this end, we employed the VJM paradigm [6], in which joystick movements serve as conditioned stimuli (CSs) and nociceptive electrocutaneous stimuli as unconditioned stimuli (USs). A reward–lottery tickets with which participants could win a self-selected prize–functioned as a competing goal. Furthermore, participants were a priori classified in three groups, depending on which goal they considered most important: the pain-avoidance goal, the reward-seeking goal, or both goals valued as equally important. We expected that installing a competing goal would lead to decreases in pain-related fear, and less hesitation to perform the painful (CS+) movements, as well as making the choice to avoid pain less often. Moreover, we expected that goal prioritization would moderate these effects, with the strongest effects for participants preferring to obtain the reward, and the smallest effects for people preferring to avoid pain.

## 2. Methods

### 2.1 Participants

Participants were recruited by means of flyers and online advertisements. Sixty-five healthy individuals (28 male; $M_{age}$ = 22.51 years, $SD_{age}$ = 2.13) participated, for which they received € 12.
Exclusion criteria were insufficient knowledge of the Dutch language, cardiovascular diseases, lung diseases, neurological diseases, other serious medical conditions, a current diagnosis of psychiatric disorders, chronic or acute pain, being asked to avoid stressful situations by a general practitioner, presence of electronic medical devices (e.g. pace-maker), anxiolytics or antidepressants, pregnancy, and deteriorated vision that is not corrected. All participants gave informed consent. The experimenter (female) informed that participation was voluntary, and could be discontinued at any time and for any reason, without negative consequences. Ethical approval was obtained through the Ethics Committee of the Faculty of Psychology and Educational Sciences of the University of Leuven (Belgium). Three participants did not adhere to the experimental instructions. Five other participants indicated that both earning tickets and pain-avoidance were *un*important. These eight participants were excluded from further statistical analyses, as we reasoned that the experimental manipulation failed. The final sample consisted of 57 participants (21 male; $M_{age}$ = 22.26 years, $SD$ = 1.64). Based on the self-reported identification of the most important goal, participants were classified in three groups: *pain-avoidance* (N = 19; $M_{age}$ = 22.1,

$SD_{age}$ = 1.6; 4 males), *reward-seeking* (N = 21; $M_{age}$ = 22.9, $SD_{age}$ = 2; 11 males), and *equally important* (N = 17; $M_{age}$ = 22.3, $SD_{age}$ = 2; 9 males).

## 2.2 Design summary

The experiment employed a crossover within-subject design. Participants performed joystick movements in the horizontal or vertical plane for the experimental and control condition respectively, or vice versa. The order in which the conditions were completed, the movement plane, and position of the CS+ were counterbalanced across participants.

## 2.3 Apparatus and stimuli

**2.3.1 Software.** The experiment was run on a Windows XP computer (Dell OptiPlex 755; Dell, Round Rock, TX) with 2 GB RAM and an Intel Core2 Duo processor (Intel, Santa Clara, CA) at 2.33 GHz and an ATI Radeon 2400 graphics card (Advanced Micro Devices, Sunnyvale, CA) with 256 MB of video random-access memory. The experiment was programmed in Affect, version 4.0[15,41].

**2.3.2 Stimulus material.** We employed an adapted version of the VJM Paradigm [6,29]. Movements in four different directions served as conditioned stimuli (CS; either to the left, right, upward, and downward). Participants carried out these movements with their dominant hand, using a Paccus Hawk Joystick (Paccus Interfaces BV, Almere, The Netherlands). Rectangular targets on the computer screen indicated the possible movement directions. There were two types of movement trials: (a) signaled trials, in which a change in the color of the target from black to purple indicated the to-be-performed movement, (b) choice trials: in which the participant chose and performed either one of both movements. These two trial types are depicted in Figure 1.

-INSERT FIGURE 1 ABOUT HERE-

A painful electrocutaneous stimulus consisting of trains of 10 ms sinusoid pulses with a frequency of 50 Hz, delivered for 1000 ms served as aversive unconditioned stimuli (pain-US). It was delivered by an Isolated

Bipolar Current Stimulator (DS5; Digitimer ltd, Welwyn Garden City, England) through surface SensorMedics electrodes (1 cm diameter; SensorMedics Corp, San Diego, CA) filled with K-Y gel (Johnson & Johnson, New Brunswick, NJ) that were attached to the wrist of the dominant hand. Stimulus intensity was individually determined during a standard calibration procedure (see below)[29,32]. In the experimental condition, lottery tickets served as positive unconditioned stimuli (reward-US). These lottery tickets represented the chance to win a prize worth approximately 100 euros, chosen by the participant during an individual prize selection procedure (see below). One reward-US represented two lottery tickets. Upon movement completion, participants received the pain-US with or without concurrent reward-US for reinforced, painful movements (CS+), but not for safe movements (CS-).

**2.4 Self-reported measures**

**2.4.1 Goal measures.** To explore the effects of goal preference, participants indicated what their most important goal was prior to the start of the acquisition phase of the experimental condition, by selecting one of the following answer options: (1) pain avoidance, (2) earning tickets, (3) whether both goals were equally important, or (4) equally unimportant. If they wished, participants could write down why they selected the chosen option. We divided participants into three groups, based on which option was selected: *pain-avoidance, reward-seeking,* and *equally important*. Participants selecting ‘equally unimportant’ were excluded from the experiment (see above).

**2.4.2 Outcome measures.** During the experimental phase, the participants were requested after three trials to online report about their experience. Participants reported to what extent they were afraid to perform the previous movement (‘pain-related fear’). Participants also rated how painful (‘pain intensity’), how unpleasant (‘pain unpleasantness’), and how tolerable (‘pain tolerance’) the electrocutaneous stimulus was. All except one question were answered using an 11-point Likert scale. The pain intensity item was additionally rated using a verbal rating scale with the following labels: ‘mild’ – ‘moderate’ – ‘very’ – ‘immense’.

**2.4.3 Manipulation check.**

Along with the assessment of the outcome measures, participants reported to what extent they expected the electrocutaneous stimulus (‘pain expectancy’), and to what extent they expected lottery tickets (‘ticket expectancy’), using an 11-point Likert scale, ranging from 0 (not at all) to 10 (very much). These questions enabled us to check whether participants successfully learned the CS-US contingencies.

**2.4.4 Questionnaires.** Participants completed several questionnaires after the experiment via an online system. Information about participants’ age, sex, status, education and work was collected. Furthermore, participants completed the Fear of Pain Questionnaire (FPQ-III-NL)[46], the Pain Catastrophizing Scale (PCS)[43], and the Trait Positive Affectivity and Negative Affectivity Scale (PANAS)[10]. These questionnaires were collected for descriptive purposes only, and data from these questionnaires were not included in any of the statistical analyses.

**2.5 Response latency**

Response latency was the time (in seconds) that participants needed to initiate the movement, more specifically, the time between the presentation of the starting signal (a fixation cross) and leaving the start region (a small circle in the middle of the computer screen) [4,6,34].

**2.6 Behavioral decisions**

During choice trials, participants chose which movement they wanted to perform: the CS+ or the CS- movement. Participants completed twelve choice trials per condition. For each choice trial, the decision was registered. The choice for a painful movement was coded as 1, the choice for a safe movement as 0. The sum of the number of times the participants chose to perform the painful (CS+) movement was calculated per participant per condition, yielding a number between 0 and 12. This sum served as a measurement index of avoidant decision making behavior, with higher values indicating fewer avoidant decisions [6].

**2.7 Choice switches**

The number of times that participants switched between the CS+ and CS- movements during the choice phase were also calculated per condition. Switching was coded as 1, not switching was coded as 0. The sum per condition, varying from 0-12, served as an index of behavioral persistence, with lower numbers indicating higher persistence[14,33,40].

**2.8 Procedure**

At the beginning, participants were informed that the objective was to study the effects of different types of distractors on motor movements, and that painful electrocutaneous stimuli would be administered as part of the procedure. The experiment consisted of 5 phases and lasted about 90 minutes. The experimental design is presented in Table 1.

-INSERT TABLE 1 ABOUT HERE-

**2.8.1 Stimulus calibration phase.** The experimenter informed participants that painful electrocutaneous stimuli would be administered in order to individually determine the stimulus intensity level. The aim was to select a stimulus that was painful and required some effort to tolerate. When participants no longer wished to increase stimulus intensity, they notified the experimenter. The experimenter asked the participant whether s/he agreed with repeatedly receiving stimuli of maximally the selected intensity during the subsequent phase(s).

**2.8.2 Practice Phase.** In the subsequent practice phase, participants rehearsed performing joystick movements and familiarized themselves with the task. Participants were required to perform the joystick movements towards a target as fast and as accurately as possible, and as soon as the start signal (fixation cross, '+') appeared. Further instructions stated that the to-be-performed movement was either signaled by a purple coloring of a rectangular target, or, when indicated on screen, could be freely chosen by the participant. When a movement was successfully performed, the corresponding target turned yellow. Participants did not receive any pain- or reward-USs during this phase. Participants received immediate visual feedback during the movements. A cursor on the screen indicated the position of the joystick during the movement, and an error message was displayed when participants performed an incorrect movement. The experimenter monitored the participants' movements via a closed-circuit-TV-installation and provided tailored feedback via intercom if needed. Participants completed 2 blocks of 5 practice trials: the first block consisted of 4 signaled movements in the horizontal movement plane (2 left, 2 right), and one choice trial. In the second block, movements were conducted in the vertical movement plane (upward/downward). A trial consisted of a 1.5 s-presentation of the fixation cross, and performance of the CS movement, which varies in length, depending on participant's movement speed. Inter trial Intervals (ITI) were 8 s in duration. The trial timing of a signaled trial is depicted in Figure 2.

-INSERT FIGURE 2 ABOUT HERE-

**2.8.3 Experimental Phase.** The experimental phase consisted of two separate conditions, the control and experimental condition. The order in which both conditions were completed was counterbalanced across participants. In each condition, participants were instructed to perform the movements as fast and as accurately as possible upon appearance of the fixation cross.

***Control condition***. The experimenter informed participants that an electrocutaneous stimulus of varying intensity but maximally the selected stimulus (pain-US) would follow one movement (CS+), but not the other movement (CS-). In reality, the pain-US was always the same intensity, that is, the selected maximal intensity.

Participants then completed an *acquisition* phase, consisting of 3 blocks of 8 trials (4 CS+, 4 CS-). Which movement served as a CS+ was counterbalanced between participants. Half of the CS+ trials were reinforced, that is, followed by the pain-US, whereas the CS- was never reinforced. USs were always administered immediately after successful completion of a movement (i.e., after the target turned yellow). In every acquisition block, participants rated pain-related fear and pain-expectancy of 1 CS+ and 1 CS- movement. For the CS+ trial, pain intensity, and pain unpleasantness were also rated. Immediately following the acquisition phase, a test phase (one block of 12 CS+ and 12 CS- trials) took place testing our hypotheses. Again, reinforcement rate was 50%. Participants rated pain-related fear and pain-expectancy, and if applicable pain intensity and unpleasantness for 3 CS+ and 3 CS- movements. In the subsequent *choice phase,* participants were informed via instructions on the computer screen that they could choose which movement, either the CS+ or the CS-, they performed. The instructions emphasized that the same movement (CS+) would be followed by the pain-US, whereas the other movement (CS-) would not. In total, 4 blocks of 3 choice trials (12 movements in total) were completed. CS+ movements in the choice phase were 100% reinforced. Trial timing was identical to the practice phase.

***Experimental Condition.*** The experimental condition was highly similar to the control condition, except for the following: (a) prior to the experimental condition, participants were informed that they could earn lottery tickets to win an additional prize of their choice. Participants then selected one out of a list of possible prizes; (b) Participants were informed that one movement (CS+) would be followed by an electrocutaneous stimulus of varying intensity, but maximally the previously selected stimulus (pain-US) and lottery tickets (reward-US), whereas the other movement (CS-) would not. Instructions stressed that with these lottery tickets, participants could win the prize of their choice and the more tickets they earned, the higher the probability of winning the prize. Half of the CS+ trials were followed by both the Pain-US and the reward-US in the acquisition and test phase, whereas in the choice phase all CS+ trials were reinforced; the pain-US and reward-US were presented simultaneously; (c) Before the start of the acquisition phase, participants selected the goal they preferred; and (d) participants also rated ticket expectancy during the task.

**2.7.4 Debriefing**. At the end of the experiment, participants were informed about the course of the lottery and the number of tickets they had won. During the experiment, participants were instructed that the more tickets they earned, the higher the probability of winning the prize of their choice. However, unknown to the participants,, all participants had an equal chance of winning the lottery. Participants were requested to leave their e-mail address to be contacted in case they won the prize. Second, we invited participants for an e-mail debriefing where they were informed about the objectives and broader context of the experiment. At the end of the experiment, a winner was selected at random.

# 3. Results

## 3.1 Data reduction and analysis

Response latencies < 250 ms and > 3000 ms were considered outliers and therefore eliminated. Similarly, response latencies deviating more than 3 SDs from the within-subject-mean calculated for the corresponding movement (CS+/CS-) and condition (control/experimental) were excluded from further analysis. 2 × 2 [Condition (control/experimental) × CS type (CS+/CS-)] Repeated Measures ANOVAs with Group (pain-avoidance/equally important/reward-seeking) as between-subjects variables were run for the self-reported measures and response latencies. For decision making behavior and choice switches, ANOVAs with Condition as within-subject variable and Group as between-subjects variable were carried out. Follow-up planned contrasts were calculated when appropriate. All statistical analysis were run with SPSS 22.0[18]. Greenhouse Geisser corrections were reported when appropriate. Effect sizes were calculated using general eta squared ($\eta^2_G$), with values of .2, .13, and .26 respectively indicating a small, medium, and large effect[2,24,35].

## 3.2 Descriptive statistics

The average intensity of the painful electrocutaneous stimulus was 12.2 mA (*SD* = 4.6). Participants scored on average 19.2 (*SD* = 9.3) on the PCS, and 69.9 (*SD* = 16.2) on the FPQ-III-NL. Mean scores on the positive affectivity and negative affectivity scale of the PANAS were 35.7 (*SD* = 4.3) and 20.7 (*SD* = 5.7) respectively. There were no significant differences between groups on these variables. Participants earned on average 40 (*SD* = 8.9) lottery tickets. However, there was a significant difference between groups, $F$ (2,54) = 21.73, $p < 0.001$. The *pain-avoidance* group earned on average fewer lottery tickets (M=32, *SD* = 8.4), than the *equally important* group (*M* = 41, *SD* = 8), who in turn earned fewer tickets than the *reward-seeking* group (*M* = 46, *SD* = 3.1).

## 3.3 Self-reported measures (see Table 2)

**3.3.1 Manipulation check** For the pain-expectancy measure, analyses revealed a significant main effect of CS type, $F$ (1,54) = 84.26, $p < .001$, $\eta^2_G = .439$.This effect did not interact with Condition, *F* <1, nor differ between Groups, *F* < 1, indicating that participants successfully associated the CS+ movement but not the CS- movement with the pain-US. Similarly, for the ticket-expectancy measure there was a significant main effect of CS type, *F* = 122.71, *p* < .001, $\eta^2_G$ = .557, but no significant interaction between CS type × Group, *F* < 1, suggesting that participants successfully learned that the reward accompanied the CS+ but not the CS- in the experimental condition, irrespective of their goal preference.

**3.3.2 Outcome measures**. Statistical analysis for the pain-related fear measure yielded a significant main effect of CS type, *F*(1,56) = 58.26, *p* < .001, $\eta^2_G$ = .266, as well as a main effect of Group, *F* (2,54) = 4.33, *p* = .018, $\eta^2_G$= .07, but no significant interaction between both variables, *F* < 1. Planned pairwise comparisons revealed that overall, the reward-seeking group reported less pain-related fear compared to the equally important group, *t*(54) = -1.47, *p* = .031. The reward-seeking group tended to report less pain-related fear than the pain-avoidance group, but this difference did not reach statistical significance, *t*(54) = -1.267, *p* = .067. The pain-avoidance group and equally important group did not differ in self-reported pain-related fear, *t*(54) = -0.203, *p* = 1. No main effect or interactions with the variable Condition were found.

Repeated Measures ANOVA with Condition as within subjects-variable and Group as a between-subjects variable revealed that participants did not find the painful electrocutaneous stimulus less painful when a reward was presented, main effect Condition: *F* < 1. There was no significant main effect of Group, *F*<1, nor was there a significant interaction Condition × Group, *F* (2,54) = 1.59, *p* = .214, $\eta^2_G$ .009. Similarly, participants also did not find the electrocutaneous stimulus less unpleasant when a reward was presented compared to when a reward was not presented, main effect Condition: *F(*1,54) = 2.33, *p* = .133, $\eta^2_G$ = .005. There was no difference between groups either; main effect Group: *F*< 1.

### 3.4 Response latencies (see Table 2)

For response latency, a significant main effect of CS type emerged, *F*(1,54) = 6.43, *p* = .014, $\eta^2_G$ = .005, and this effect did not interact significantly with Condition nor Group, *F* (2,54) = 1.19, *p* = .281,

$\eta^2_G$< .001; *F* < 1, respectively, indicating that participants are slower in initiating the CS+ movement compared to the CS- movement, irrespective of group or condition. Mean scores per condition and group of the self-reported measures and response latencies are presented in Table 2.

-INSERT TABLE 2 ABOUT HERE-

### 3.5 Behavioral decisions

Participants chose to perform the painful movement more often when the reward-US was presented, compared to when the reward was not presented; main effect Condition: $F(1,54) = 166.03$, $p < .001$, $\eta^2_G = .557$ . Similarly, the number of painful movements performed is moderated by Group, $F(2,54) = 19.02$, $p < .001$, $\eta^2_G = .294$. The Group × Condition interaction was also significant, $F = 11.53$, $p < .001$, $\eta^2_G = .148$. Planned pairwise comparisons revealed that each Group performed more painful movements in the experimental than in the control condition, *Pain-avoidance*: $t(18) = 3.69$, $p = .002$; *Reward-seeking*: $t(20) = 16.81$, $p < .001$; *Equally important*: $t(16) = 6.024$, $p < .001$. Furthermore, results showed that when the reward was presented, participants preferring pain-avoidance (Pain-avoidance Group) performed fewer painful movements than participants considering both goals equally important, $t(34) = -3.327$, $p = .002$. Participants from the latter group performed fewer painful movements than the participants who preferred to obtain the reward (Reward Group), $t(19.54) = 2.386$, $p = .027$. The number of painful movements performed during the choice phase per Condition and Group is presented in Figure 3.

-INSERT FIGURE 3 ABOUT HERE-

### 3.6 Choice switches

For choice switches, neither the main effects of Condition nor Group were significant, $F < 1$. The Condition × Group interaction however, was significant, $F(2,54) = 7.51$, $p = .001$, $\eta^2_G = .12$. Further analyses revealed that the participants who indicated that they preferred pain-avoidance, persisted in avoidance when there was no reward, but they were more flexible when the reward was presented, $t(18) = 2.557$, $p = .02$. The reward-seeking group on the other hand, were persistent in selecting the painful movement when accompanied by the reward, but switched more often between the painful and the safe movements when there was no reward, $t(20) = -2.726$, $p = .013$. The equally important group however was equally flexible in both conditions, $t(16) = .079$, $p = .938$. The number of choice switches between painful and safe movements during the choice phase per Condition and Group is presented in Figure 4.

-INSERT FIGURE 4 ABOUT HERE-

## 4 Discussion

This study investigated whether a competing reward-seeking goal resulted in diminution of pain–related fear and avoidance behavior. Additionally, we investigated whether goal prioritization moderated this effect. For this purpose, we used the VJM paradigm [6,29]. In the control condition, participants performed movements in two different directions. One movement was accompanied by a painful stimulus, whereas the other was not. In the experimental condition, performing a painful movement also resulted in earning lottery tickets, thusly creating a competition between pain-avoidance and reward-seeking tendencies.

The results can be summarized as follows. First, participants readily learned to differentiate the painful and safe movements, and which movement co-occurred with the reward. Second, participants who indicated a preference for the reward reported less pain-related fear. However, pain-related fear was unaffected by a reward during the painful movement, as was the case in our previous study [6]. Third, participants were more hesitant performing a painful movement than a safe movement, irrespective of their preferred goal, and irrespective of the presence of the concurrent reward. Fourth, participants performed more painful movements when a concurrent reward was present than when it was absent. Moreover, the number of painful movements performed was affected by participants' preferred goal.

More specifically, participants who indicated that they preferred to avoid pain, performed fewer painful movements than participants finding both goals equally important, who in turn performed fewer painful movements than participants indicating to be eager to earn the reward. Fifth, goal preference influenced the number of times that participants switched between performing a painful and a safe movement, or vice versa, which is indicative of behavioral persistence[14,33]. It seems that when participants preferred to avoid pain, they were rather persistent when nothing could be gained by the painful movement, whereas they switched more often when a concurrent reward was present. Conversely, participants who preferred the reward, persisted in selecting the painful movement when accompanied with the reward-US, but at times avoided the painful movement when there was no reward.

Overall, the results of this study corroborate the view that avoidance behavior is a dynamic response that is not only influenced by pain and associated responding, but also by contextual factors and competing goals such as obtaining a reward [9,45]. As such, avoidance behavior may vary within individuals depending on the situation. Furthermore, this study further demonstrates that although self-reported pain-related fear remains unaltered, pursuing a competing goal may result in a diminution of observable avoidance behavior [21,42,45]. Moreover, goal preference seems to moderate this effect. This finding is in line with the idea that pursuing one goal, i.e., performing movements to earn tickets, may inhibit conflicting goals, i.e., avoiding the same movement to deter a painful stimulation [11,36]. Current fear-avoidance models however have difficulties explaining such findings, and would therefore benefit from including theories on behavioral decision making as well as goal pursuit [7,45]. More specifically, more insight is needed in the mechanisms underlying the incorporation of competing goals and their influence on avoidance behavior. One interesting avenue to explore is the impact of differences in value of the different goals and the expected outcome (i.e., the probability of successful goal attainment) on pain-related fear and avoidance behavior [8,17,45].

Our findings may have implications for clinical practice. First, the assessment of goals and goal importance might help us identify the person's valued life goals that compete with the goal to avoid pain. Identifying the situations in which individuals experience goal conflict or prioritize pain avoidance over other life goals may shed more light on the reasons why they are prone to engage in avoidance behavior. Although identification of goal prioritization has been clinically advocated, research on the presence of goal conflicts in patient populations and the underlying mechanisms is still lacking. Our study is one of the first to suggest that prioritizing non-pain goals over pain avoidance goals might instigate individuals with chronic pain to expose themselves to daily activities, even though they are painful, whereas prioritizing pain avoidance instigates avoidance behavior. Second, the current study provides evidence that avoidance behavior is the result of not only pain-related characteristics, but also of contextual features such as pain-avoidance goals and reward-seeking goals. Indeed, the results of this study seem to corroborate that incorporating both pain-related and other, valuable life goals in treatment may be a more effective method to optimize treatment outcome, instead of focusing on pain-related fear alone [5,7,38]. Third, the results indicated that pain avoidance could be overcome by introducing a competitive valuable reward, even when participants considered pain avoidance as their most important goal. Thus, the current experiment provides further experimental evidence for interventions that bolster the importance of patients' relevant life goals, so that patients may leave the path of avoidance, and venture to be active despite pain [13,38,45]. Examples of such already existing interventions are motivational interviewing, (contextual) cognitive-behavioral treatments, graded activity, and exposure in vivo[19,20,28,38,52].

There are some limitations to consider. First, the sample used in this experiment included mostly healthy, undergraduate students, thus restricting generalizability to general and patient samples. In a related vein, we operationalized goal competition by introducing a concurrent reward when painful movements are performed. Although the use of monetary incentives has been effective in installing a reward-seeking goal previously in experimental settings [42,47,48], the ecological validity of using such a manipulation in a clinical sample is probably limited. Third, the grouping of participants was based upon self-reported preferences, and was not experimentally manipulated. One should therefore be careful with making causal inferences. Fourth, the current study only made use of self-reports and behavioral measures to investigate the hypotheses. To further corroborate these findings, future studies may include psychophysiological measures as well, such as the eye blink startle reflex [26,29] and pupil dilatation

[1,25]. Fifth, we did not replicate the finding of Claes et al. that participants respond equally fast to the CS+ than to the CS- movement when a reward is presented [5]. A difference in the operationalization of response latency no longer enabled participants in the current study to prepare and assess the situation before actually having to perform the movement, which may account for the difference in responding towards the painful and safe movement [34]. Lastly, our hypotheses were tested in a test phase, in which both goals were kept active by using intermittent reinforcement. It would be interesting to investigate what the effects of competing goals and goal prioritization on pain-related fear and avoidance behavior are in an extinction context. Such situations might reveal whether participants persist in their behavior when there is no further reinforcement. Despite these limitations, the results of the present study seem to indicate that including a reward diminishes avoidant decision making behavior, leaving pain-related fear unchanged. Moreover, goal preferences appear to moderate these effects.

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## Figures

**Fig. 1.** Types of trials. (a) Signaled trials: to-be-performed movements are signaled by the purple coloring of the target; (b) Choice trials: the participant choose and perform one of both movements.

**Fig. 2.** Trial timing. The trial timing is depicted for a signaled trial. Trial timing is fairly similar for a choice trial, with the difference that there is no purple coloring of the target, but an instruction to choose and perform one of both movements. Here, the vertical movement plane is depicted. Note that movement plane is counterbalanced between conditions and between participants. Fifty percent of the CS+ movements are followed by the pain-US alone in the control condition, and by both the pain-US and reward-US in the experimental condition. The CS- movement is never reinforced. An arrow indicates the performed CS movement.

**Fig. 3.** Average number of painful movements performed during the Choice phase.

**Fig. 4.** Average number of choice switches during the Choice phase.

Table 1

*Experimental design*

| *Condition* | Practice | Experimental phase | | |
|---|---|---|---|---|
| | | Acquisition | Test | Choice |
| *Control* | 2 { 2 $CS_{left}$, 2 $CS_{right,}$ 1 $CT_{left/right}$} 2 { 2 $CS_{up}$, 2 $CS_{down}$, 1 $CT_{up/down}$} | 3 {4 CSp+, 4 CS-} | {12 CSp+, 12 CS-} | 3 { 4 CT} |
| *Experimental* | | 3 {4 CSrp+, 4 CS-} | {12 CSrp+, 12 CS-} | 3 { 4 CT} |

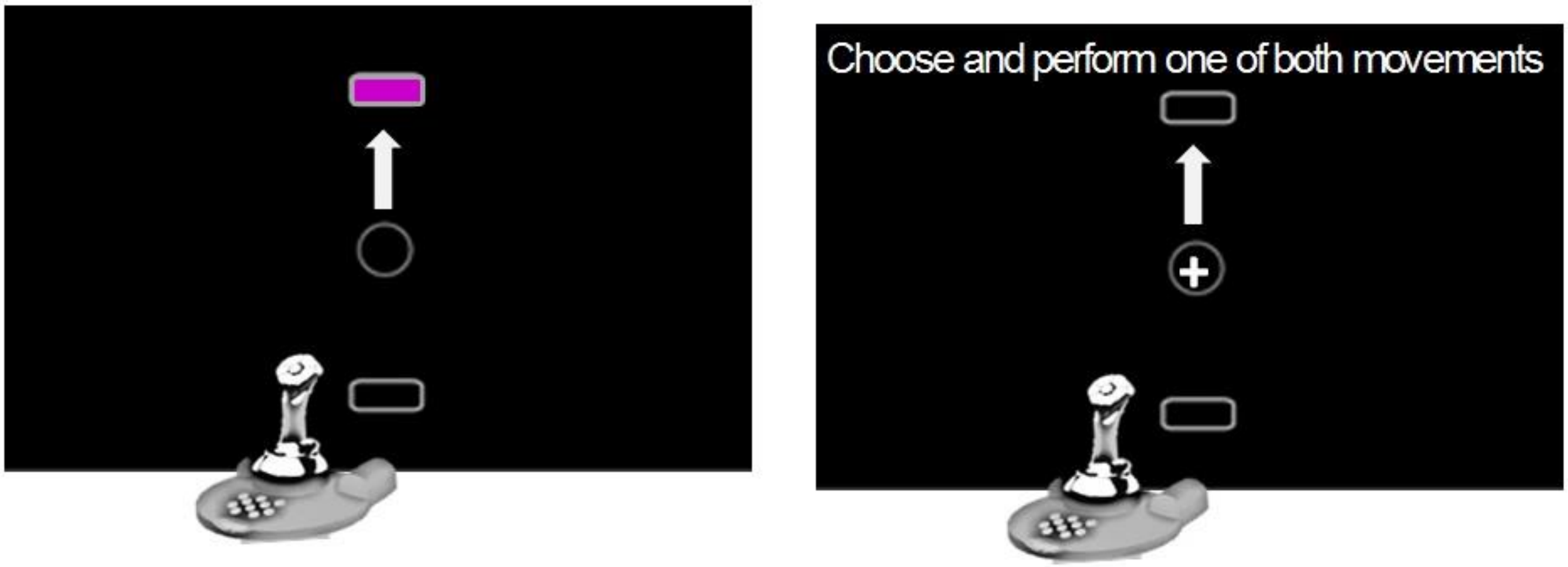
*Note*: Both conditions are performed by all participants in counterbalanced order. All participants complete the practice phase only once, before the start of the experimental phase. CS indicates the conditioned stimulus, that is, joystick movements, that are either reinforced (+) or non-reinforced (-). CT indicates a choice trial, indicating trials where participants choose and perform either the CS+ or the CS- movement. A p indicates that a pain-US was administrated, and an r signals that the movement was followed by a reward-US. In the acquisition and test phase, CSs+ were reinforced in half of the trials (50%), whereas in the choice phase, choosing the CS+ movement always resulted in the administration of the pain-US (control) or both the pain-US and the reward-US (experimental).

Table 2

*Mean and SD per CS type, Group and Condition for all self-reported measures and response latencies*

| | | Total | Pain-avoidance | Reward-seeking | Equally Important |
|---|---|---|---|---|---|
| Variable | Stimulus | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) |
| **Control Condition** | | | | | |
| Pain intensity | CS+ | 6.7 (1.5) | 6.7 (1.8) | 6.6 (1.3) | 7 (1.4) |
| Pain unpleasantness | CS+ | 7.4 (1.6) | 7.3 (2) | 7.3 (1.3) | 7.6 (1.3) |
| Pain-US expectancy | CS+ | 7.5 (1.8) | 7.4 (1.7) | 7.3 (2) | 7.7 (1.7) |
| | CS- | 3.2 (3.2) | 3.4 (3.5) | 2.9 (3.2) | 3.4 (3.1) |
| Pain-related fear | CS+ | 5.6 (2.5) | 5.5 (2.5) | 4.9 (2.8) | 6.6 (2) |
| | CS- | 2.4 (2.5) | 2.8 (2.8) | 1.9 (2.3) | 3 (2.6) |
| Response Latencies (ms) | CS+ | 451 (155) | 513 (202) | 397 (109) | 447 (122) |
| | CS- | 440 (125) | 483 (153) | 412 (114) | 424 (92) |
| **Experimental Condition** | | | | | |
| Pain intensity | CS+ | 6.7 (1.5) | 6.9 (1.6) | 6.6 (1.1) | 6.5 (1.9) |
| Pain unpleasantness | CS+ | 7.1 (1.7) | 7.1 (2.2) | 7.2 (1.3) | 7.2 (1.8) |
| Pain-US expectancy | CS+ | 7.4 (1.7) | 7.7 (1.5) | 7 (1.7) | 7.5 (2) |
| | CS- | 3.2 (2.9) | 3.5 (3.1) | 2.8 (2.8) | 3.4 (3.1) |
| Ticket-US expectancy | CS+ | 7 (1.5) | 6.5 (1.6) | 7 (1.6) | 7.6 (1.1) |
| | CS- | 2.6 (2.4) | 2.7 (2.3) | 2.5 (2.6) | 2.7 (2.6) |
| Pain-related fear | CS+ | 5.6 (2.3) | 6.3 (2.1) | 4.6 (2.4) | 6 (1.9) |
| | CS- | 2.8 (2.7) | 3.5 (2.9) | 1.6 (2.1) | 3.2 (2.8) |
| Response Latencies (ms) | CS+ | 483 (210) | 533 (238) | 436 (149) | 486 (238) |
| | CS- | 450 (174) | 500 (241) | 404 (127) | 451 (121) |

Figure 1




**(a) Signaled trials** **(b) Choice trials**

Figure 2

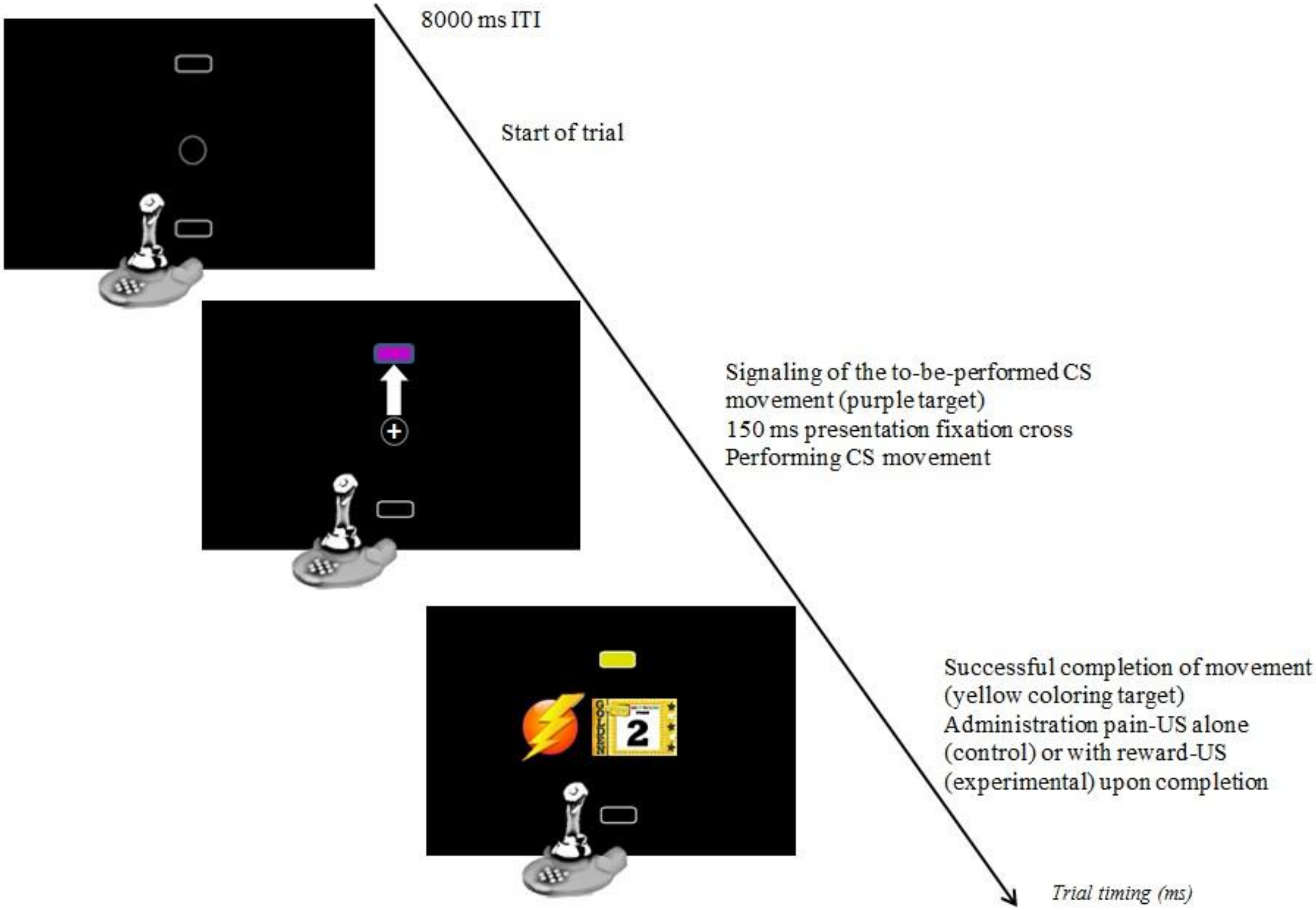

8000 ms ITI
Start of trial
Signaling of the to-be-performed CS movement (purple target)
150 ms presentation fixation cross
Performing CS movement
Successful completion of movement (yellow coloring target)
Administration pain-US alone (control) or with reward-US (experimental) upon completion
Trial timing (ms)
2

Figure 3

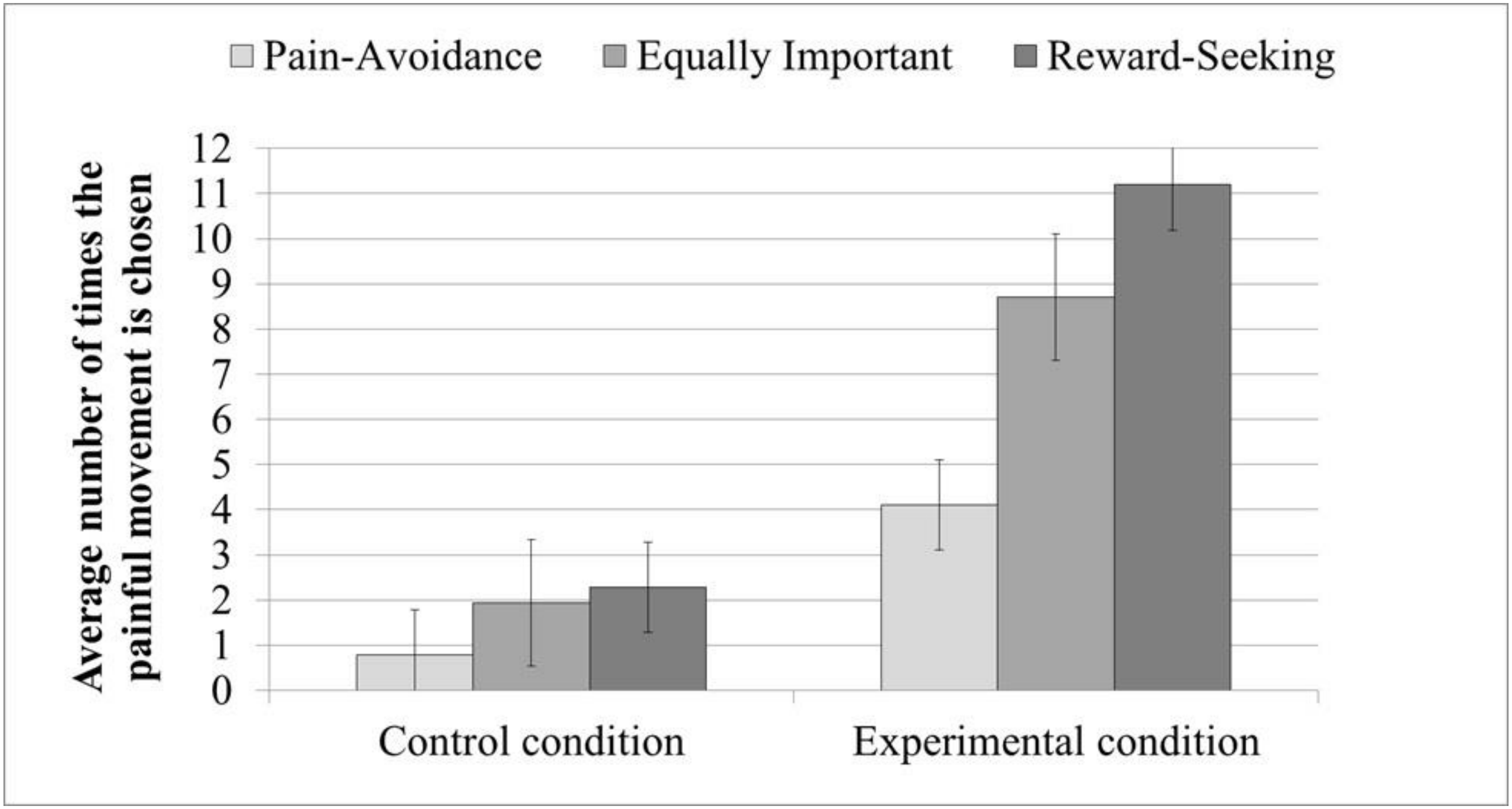
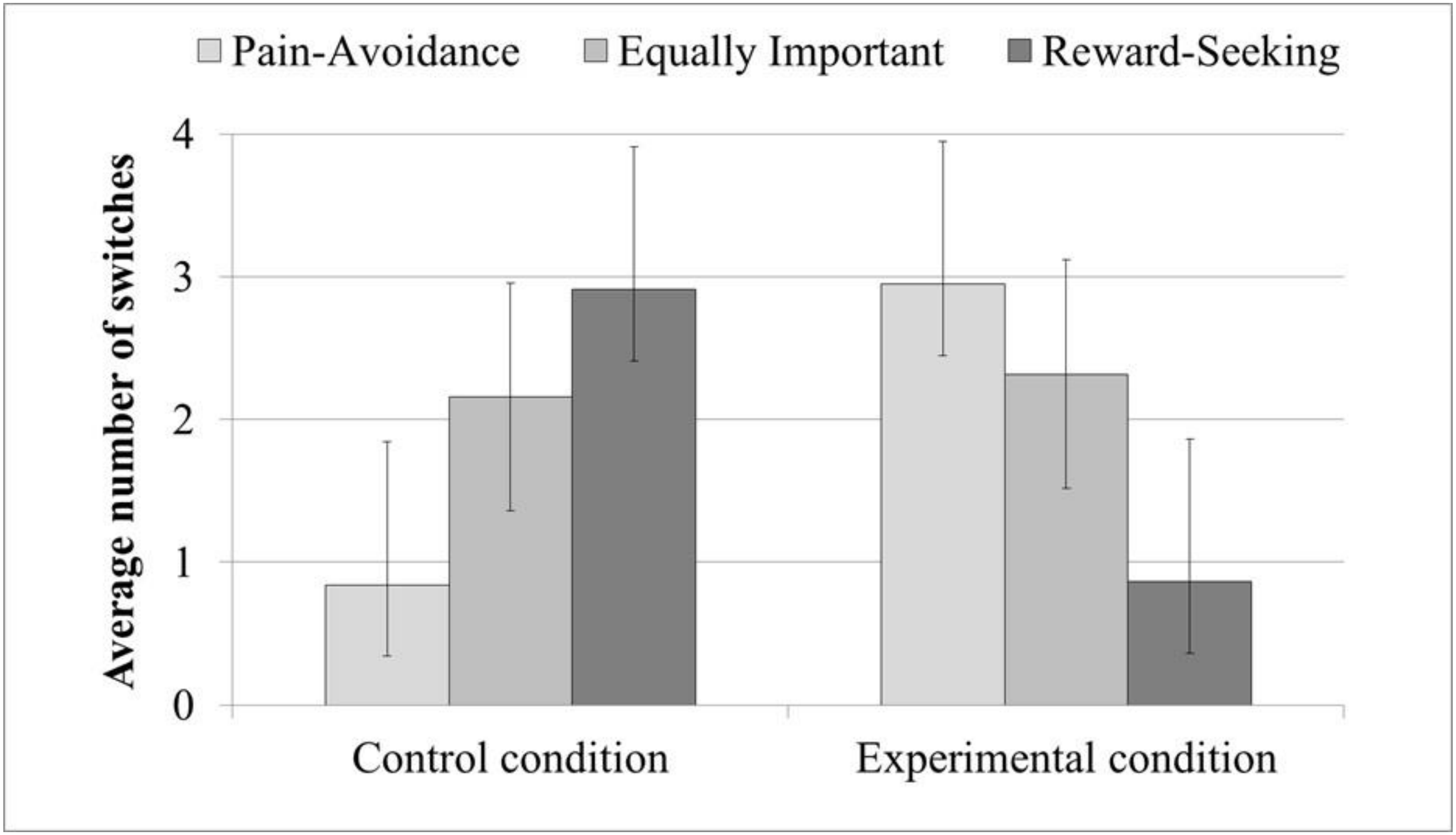

Pain-Avoidance
Equally Important
Reward-Seeking
Average number of times the painful movement is chosen
0
1
2
3
4
5
6
7
8
9
10
11
12
Control condition
Experimental condition

Figure 4


Pain-Avoidance
Equally Important
Reward-Seeking
Average number of switches
0
1
2
3
4
Control condition
Experimental condition