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Combining Prolonged Heat Pain with Low Controllability Over Rewards and Losses Results in Minimal Effects on Value-Based Decision-Making

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Preface

The idea for the present thesis has been introduced to me by Gábor Csifcsák who also became my supervisor. This vast project was divided into three smaller sister projects and I got to collaborate with Caroline Alexandra Grant Angen and Ina Klakegg. With supervision of Gábor Csifcsák and with advices from Matthias Mittner, we developed a pain protocol after conducting a pilot study on ourselves and the employees of Psychology Department. Further, we used in total around 150 hours on collecting the necessary data from 100 participants. Me, Caroline and Ina focused on different hypotheses and analyzed the statistical data accordingly under the guidance of Gábor.

First and foremost, I want to say thank you to my supervisor Gábor. His supervision was outstanding. I have received a thorough introduction to the present research´s topic, help, guidance, constructive feedback, corrections, inspiration, encouragement and an overall major contribution to the end result.

This two-year journey in the master´s course of psychology has provided me with insight, new theoretical and practical knowledge, personal development and devotion to research and writing. For that I thank the master course coordinators Tove Irene Dahl and Mikolaj Hernik, as well as coordinators of other courses within the master program.

Lastly, I want to thank my master colleagues, Caroline and Ina. They have been diligent throughout this endeavor, and in turn I aspired to be like them.

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Sammendrag

Tidligere forskning har vist at eksperimentelle manipulasjoner som sikter på å indusere valgstrategier som ligner lært hjelpeløshet (LH) påvirker meklingen mellom enkle og komplekse beslutningsstrategier hos friske voksne. Forskning vedrørende beslutningstaking og LH-manipulasjoner med eksperimentell smerte mangler imidlertid. Denne studien kombinerte den nye LH-induksjonsmetoden med langvarig varmesmertestimulering under en læring-ved-forsterkning oppgave. 75 friske voksne ble tilfeldig fordelt i tre grupper (n = 25). Deres ytelse ble målt i en modifisert ortogonalisert Go/NoGo-oppgave kamuflert som et kortspill. Oppgaven besto av fem runder med fire kort i hver, hvor kortene var forskjellige når det gjaldt handling-utfall assosiasjoner. To av de tre gruppene gjennomgikk manipulasjoner i runde 2 og 4. Begge de eksperimentelle gruppene gjennomgikk en lav kontrollerbarhetsmanipulasjon (LC), med en gruppe som samtidig fikk smertestimulering (LC-P). Vi predikerte at i manipulasjonsrundene og de følgende ikke-manipulerte rundene, de eksperimentelle gruppene ville utøve motivasjonell skjevhet og suboptimal valgatferd, med en sterkere effekt i LC-P. Sammenligninger mellom grupper viste ingen forskjeller mellom LC- og LC-P-gruppene i noen av målingene gitt av denne studien, men de nåværende manipulasjonene klarte å redusere deltakernes subjektive vurderinger av opplevd kontroll og suksess i begge gruppene i manipulasjonsrundene. Disse funnene indikerer at våre LH- og smerteinduksjonsmetodene er begrenset. Derfor ble begrensningene og implikasjonene for fremtidig forskning diskutert.

Nøkkelord: lært hjelpeløshet, varmesmerte, Pavloviansk skjevhet, læring-ved-forsterkning, verdibasert beslutningstaking

Abstract

Previous research has shown that experimental manipulations aiming at inducing choice strategies resembling learned helplessness (LH) in healthy adults influence the arbitration between simple and complex decision-making strategies. However, research regarding decision-making and LH-manipulations with experimental pain is lacking. Therefore, the present study applied the new LH-induction method with add-on prolonged heat pain stimulation during a reinforcement learning task. 75 healthy adult participants were randomly assigned to three groups (n = 25). Their performance was measured in a modified orthogonalized Go/NoGo task camouflaged as a card game. The task consisted of five blocks with four cards in each, in which cards differed in terms of action-outcome associations. Two of the three groups underwent manipulations in block 2 and 4. Both experimental groups underwent a low controllability (LC) manipulation, whilst one group also received pain stimulation (LC-P). We predicted that, in manipulation blocks and the following non-manipulated blocks, the experimental groups would exert motivational bias and suboptimal choice behavior, with a stronger effect in LC-P. Between-group comparisons showed no differences between the LC and LC-P groups in any measurements provided by the present study. Nevertheless, the present manipulations managed to reduce participants´ subjective ratings of perceived control and success in both groups in the manipulation blocks. These findings indicate that our current LH- and pain-induction methods and the translational value thereof are limited. Therefore, the limitations and implications for future research were provided.

Keywords: learned helplessness, heat pain, Pavlovian bias, reinforcement learning, value-based decision-making

Combining Prolonged Heat Pain with Low Controllability Over Rewards and Losses Results in Minimal Effects on Value-Based Decision-Making

Each decision we make has a greater or lesser impact on our personal lives and the surrounding environment. Value-based decisions, for instance, help us make choices based on the subjective value we assign to them (Rangel et al., 2008). In order to make a choice, we need to consider, evaluate, compare and select from several choice alternatives, but it all comes down to our behavioral goal to approach favorable and avoid unfavorable outcomes. However, if we exclusively approach something that is subjectively good and avoid something that is subjectively bad, we risk engaging in suboptimal decision-making. Therefore, in order to make optimal decisions we need to engage in different decision-making strategies at the time of choice.

Guitart-Masip et al. (2014) has emphasized the mutual role of action and valence when it comes to balancing between different valuation systems in order to act optimally. The so-called Pavlovian valuation system operates in a valence-dependent fashion, meaning that its actions are facilitated by valence, reflexively associating an attractive stimulus with a favorable outcome which should be approached and an aversive stimulus with an adverse outcome which should be avoided (Guitart-Masip et al., 2014). Therefore, the Pavlovian system has a limited behavioral repertoire as it involves preparatory behaviors guided by stimulus cues (Rangel et al., 2008). However, immediate Pavlovian behavior can be evolutionary appropriate (Dayan et al., 2006) and adaptive when proper evaluation demands time and is cognitively costly (Rangel et al., 2008). Rangel et al. (2008) emphasized that even though the Pavlovian system does not require complex computations when it comes to assigning value to decisions, these Pavlovian behaviors are still value-based since they can compete with and hinder other valuation systems, such as the instrumental system.

The instrumental system consists of habitual (model-free) and goal-directed (model-based) processes learning to assign value to a magnitude of actions. The habitual system enables the learning of coupling actions to respective outcomes through trial-and-error (repeated training), while the goal-directed system enables the learning of how to use outcomes and already acquired mental representations of the environment to subsequently update and adjust future actions in order to achieve a goal (Dayan & Berridge, 2014). Therefore, relative to the hard-wired Pavlovian system, the instrumental system provides a flexible alternative to learning how to encourage or inhibit actions in order to obtain rewards or avoid losses irrespective of valence (Guitart-Masip et al., 2014; Rangel et al., 2008).

Although the two systems assign value to approach and avoidance behaviors differently (Rangel et al., 2008), they interact. Therefore, upon action selection they can either cooperate or compete for potential choice options (Dayan et al., 2006). Multiple studies have used different types of Go/NoGo reinforcement learning tasks to investigate the arbitration between Pavlovian and instrumental behaviors based on action-valence interactions. The task involves four behaviors, where two of them are linked to the valence-dependent Pavlovian system of performing an action in order obtain reward (Go-to-Win) and withholding an action in order to avoid loss (NoGo-to-Avoid-Losing). On the other hand, the valence-independent instrumental system allows all four behaviors including the two aforementioned behaviors in addition to action in order to avoid loss (Go-to-Avoid-Losing) and inaction in order to obtain reward (No-Go-to-Win) (Guitart-Masip et al., 2014). These studies have shown that healthy adults are better at learning to perform Pavlovian-congruent valence-dependent actions while Pavlovian-incongruent valence-independent actions impose Pavlovian conflict (Cavanagh et al., 2013; Guitart-Masip et al., 2012; Swart et al., 2017, 2018). A widely agreed explanation is that the Pavlovian valuation overrides the instrumental valuation system resulting in biased behavior, or the so-called Pavlovian biases.

In a normal day-to-day life, Pavlovian biases can lead to erroneous decision-making. For instance, even though the instrumental system specifies that a long-term goal (e.g. a healthier diet) can only be achieved at the expense of avoiding immediate reward (e.g. tasty food), the Pavlovian system can interfere with instrumental reasoning in a way that one approaches (fast food for intance), when instead one needs to actively avoid (Dayan et al., 2006). When this dominance of the Pavlovian system is not desired, it has been assumed that one needs to implement cognitive control that overrides these suboptimal Pavlovian tendencies (Cavanagh et al., 2013; Swart et al., 2018). Nevertheless, Pavlovian bias can be intensified under certain conditions such as depression, which tends to skew behavior towards extensive avoidance (passivity or freezing) while discouraging approach behavior (Nord et al., 2018). The present study particularly focused on the condition of learned helplessness, a major symptom of depression (Pryce et al., 2011), which emerges from perceived lack of control (Eshel & Roiser, 2010) and often co-occurs with chronic pain (Moyano et al., 2019; Samwell et al., 2006). In respect to that, I will further elaborate on the role of perceived lack of control and learned helplessness in value-based decision-making (VBDM).

Perceived (Un)Controllability of Outcomes

Perceived control is the subjective feeling of dependence between actions made and outcomes obtained (Teodorescu & Erev, 2014), but it has also been characterized as “the belief in one´s ability to exert control over situations and events in order to gain rewards and avoid punishments” (Ly et al., 2019, p. 2). Perceived control is in contrast with objective control, which is defined as the control which contains the actual existence of action-outcome relationships (Skinner, 1996). Perceived control especially serves as a predictor of how we perceive and operate in an uncertain world, and is thus important for our physical and mental well-being (Skinner, 1996).

The level of perceived control strongly varies with the level of response-outcome contingencies (also called response-feedback and action-outcome contingencies) (Ly et al., 2019; Huys & Dayan, 2009; Maier & Seligman, 2016). Response-outcome contingencies are established through trial-by-trial exploration where a specific action is repeatedly reinforced by contingent desired outcome (Maier & Seligman, 2016). Through the process of shaping these associations we eventually learn which actions are adaptive in order to obtain favorable and avoid unfavorable outcomes. However, subjectively perceived non-contingency between actions and outcomes in an environment has been linked to learned helplessness (Maier & Seligman, 2016). Learned helplessness is a behavioral inability to control aversive events and plays a role in both emergence and maintenance of the depressive state (Pryce et al., 2011).

Previous research on reward and punishment processing in depression has shown that depressed individuals tend to be more responsive to negative outcomes and often fail to use these outcomes to facilitate and improve future performance (Eshel & Roiser, 2010). Additionally, depressed individuals tend to have a generalized outlook on the world, perceiving negative events as stable and out of their control (Huys & Dayan, 2009). Such tendencies have been associated with lack of perceived control and learned helplessness (Eshel & Roiser, 2010). The feeling of helplessness is also prominent in chronic pain patients (Moyano et al., 2019; Samwell et al., 2006). These studies indicate that helplessness within chronic pain leads to passivity and the belief that the clinical condition is outside of one´s control (Moyano et al., 2019). In addition, studies point out that chronic pain patients have impaired emotional decision-making, such as in gambling tasks (Apkarian et al., 2004); reduced reward sensitivity (Elvemo et al., 2015); hypersensitivity to stressful stimuli (as cited in Borsook et al., 2016); experience less rewards since pain avoidance (passivity) is more central than seeking rewarding events (as cited in Borsook et al., 2016); and worse executive functioning on tasks that need cognitive control than tasks that need automatic processing (as

cited in Moriarty et al., 2011). Overall, chronic pain negatively impacts day-to-day life (Breivik et al., 2006).

In animal studies, multiple exposure to uncontrollable outcomes in one environment has been found to determine how test subjects evaluate controllability in a new environment. Even though the new environment offers an objective possibility to escape, the test subjects remain passive and tend to avoid exploration of alternatives due to the prior subjective experience of non-contingency (Maier & Seligman, 2016). Maier and Seligman (2016) described this phenomenon as learned helplessness, but later suggested that helplessness is not learned but is rather an automatic reaction to prolonged aversive and uncontrollable situations. However, what can be learned is overcoming this behavioral inhibition in the future by learning that one has control over the situation (Maier & Seligman, 2016). The instrumental system, for instance, and its basis in reinforcement learning can contribute to the perception of control if one engages in active exploration of alternatives (Ly et al., 2019).

Teodorescu and Erev (2014) argued that in addition to low dependence between actions and outcomes, helplessness comes from reduced exploration, as the rare occurence of rewards drives this behavior. In their study, reduced exploration rate was set as an index of learned helplessness. The authors divided participants in to two groups, and both groups underwent manipulations with the same percentage of reward frequency (how often a reward appears). However, the outcomes that the experimental group received were independent of their responses (low control group), but dependent on the responses of the control group which performed under stable response-feedback contingency (high control group). The authors showed that exploration was promoted when it was frequently rewarded (100% reward) even in the low control group. More specifically, participants who were subjected to low control in the first half of the task recovered immediately when contingencies were restored in the second half of the task, meaning that the effect of low exploration was not

transferred to the new block of trials. On the other hand, exploration was reduced in both groups when it was rarely rewarded (10% reward). However, the learned helplessness effect was detected in condition with moderate reward frequency (20%), where the low control group reduced their exploration even in the second part of the task. These results indicate that reduced exploration is not exclusively a result of a diminished response-feedback contingency, but also that it stems from how frequently rewards appear (Teodorescu & Erev, 2014).

The Role of Perceived Control in VBDM

Within the domain of VBDM, a limited amount of research has used a Go/NoGo reinforcement learning task (Guitart-Masip et al., 2012) to investigate the arbitration between instrumental and Pavlovian valuation systems under low control (Csifcsák et al., 2020, 2021; Dorfman & Gershman, 2019). By focusing exclusively on rewards, Dorfman and Gershman (2019) provided evidence for that the extent to which one is able to control rewarding outcomes influences value-based decisions. Relative to the instrumental system, the Pavlovian valuation does not rely on actions, but instead predicts the outcome based on the stimulus (Dorfman & Gershman, 2019). Therefore, Dorfman and Gershman's (2019) Bayesian arbitration model predicted that when the reward occurrence is uncontrollable (action has no effect on the outcome), the low-cost Pavlovian valuation will be favored and thus override the more effortful instrumental valuation, resulting in extensively biased behavior of approach (Pavlovian Go bias). However, when outcomes are controllable, the instrumental valuation will be favored, and people will be better at balancing their approach and avoidance behaviors towards reward (Dorfman & Gershman, 2019).

Dorfman and Gershman (2019) manipulated response-feedback contingencies of reward in a Go/NoGo reinforcement learning task. The participant's task was to decide whether to make a response (press) to a Go stimulus (40 trials) or refrain from making a

response (not press) to NoGo stimulus (40 trials) in order to receive reward. For both Go-to-Win and NoGo-to-Win stimuli the response-feedback contingency was set to 75%. In addition, participants needed to make a response to a neutral stimulus (40 trials) which was rewarded 80% of the time in the high control condition and 50% of the time in the low control condition. After each response (Go/NoGo) participants received feedback indicating their attained reward or a neutral outcome. In sum, the two groups were compared based on whether they were assigned to the high or low control condition. A key finding was that participants showed stronger Pavlovian Go bias under low control compared to the high control condition. More specifically, participants made a response (Go) more often when their overall control over outcomes was diminished (Dorfman & Gershman, 2019).

In line with Dorfman and Gershman's (2019) research on VBDM and reward-based behavior under low controllability, Csifcsák et al., (2020, 2021) additionally included punishment-based behaviors in order to study learned helplessness in VBDM. These studies used their own modified version of the orthogonalized Go/No-Go reinforcement learning task of Guitart-Masip et al., (2014). In Csifcsák et al. (2020), on the first day of the experiment, all participants completed a short version of the task. The following day, participants were divided into two groups and completed the longer version of the task. The control group had stable response-feedback contingency (70%) throughout the whole task, however just like in Teodorescu and Erev (2014), outcomes that the experimental group (low control group) received were dependent on responses of the control group. The low control group was manipulated intermittently in three within-task trial blocks scattered across a total of nine blocks. The authors found that participants who were exposed to intermittent absence of control over rewards and losses showed stronger Pavlovian bias in valence-dependent Go-to-Win and NoGo-to-Avoid trials in the manipulation blocks. More specifically, participants had stronger tendencies to act in order to win, and to remain passive in order to avoid losing in the

low control context compared to the participants who had control throughout the whole task (Csifcsák et al., 2020).

Although the Pavlovian bias was stronger in the low control group in the manipulation blocks, these manipulations did not influence further behavior in the standard blocks. That is, there was no transfer effect from the manipulation blocks to the standard blocks, which was in contrast to what the authors expected. With a successful helplessness induction in the low control group, such transfer would have occurred. The latter findings were explained based on the study of Teodorescu and Erev (2014), that is, there was a subsequent recovery when the contingency between action and outcome was restored, resulting in regained control in the standard blocks due to the frequent appearance of rewards. Therefore, in line with Teodorescu and Erev (2014), a combination of both low response-feedback contingency and moderate reward prevalence is perhaps a much stronger predictor for observing stronger behavioral effects of helplessness than originally thought. Although the study design in Csifcsák et al. (2021) differed, the results were similar to Csifcsák et al. (2020).

In their studies, Teodorescu and Erev (2014) and Csifcsák et al. (2020, 2021) measured self-reported perceived control. Teodorescu and Erev (2014) concluded that the moderate reward appearance together with a low response-feedback contingency was enough to induce learned helplessness in their study, but it was not enough to induce low self-reported perceived control. Even though Csifcsák et al. (2020, 2021) expected that the low control group would rate their levels of perceived control (and success) lower than the control group, no differences between groups were found. This finding was explained in line with Teodorescu and Erev's (2014) finding that healthy individuals' perceived control is not related to the feeling of helplessness. That is, the low controllability manipulation was not strong enough to be manifested in self-reports, perhaps because of the illusion of control (Csifcsák et al., 2020, 2021; Teodorescu & Erev, 2014), a subjective belief of that an action-

outcome relationship exists even though objectively it does not (Ly et al., 2019). This phenomenon is especially prominent in healthy individuals, as contrasted to individuals with depression who tend to be more accurate in their judgement of lacking control (Ly et al., 2019). Based on the findings of Teodorescu and Erev (2014) and Csifcsák et al. (2020, 2021), the present study manipulated not only the response-feedback contingency, but also the prevalence of reward and loss with the aim of inducing learned helplessness and investigate the arbitration between Pavlovian and instrumental choice behavior.

The Present Study

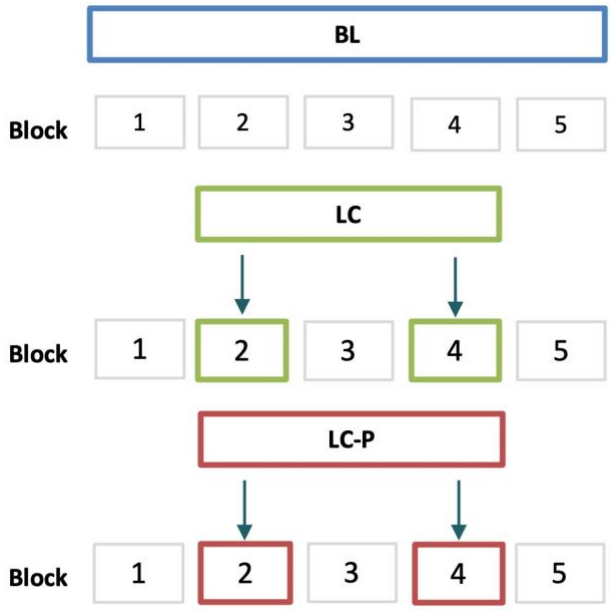
Previous, albeit a limited amount of research has shown that experimental manipulations aiming at inducing choice strategies resembling learned helplessness influenced the arbitration between Pavlovian and instrumental choice behaviors (Csifcsák et al., 2020, 2021). However, research on VBDM and learned helplessness with experimental pain in healthy participants, as well as in chronic pain patients is missing. Therefore, the present study was based on a rationale that that the experience of persistent pain and the perceived loss of control over such aversive stimulus, as well as viewing it as inescapable, contributes to the feeling of helplessness. Based on that, the present study sought to investigate whether experimentally-induced prolonged heat pain stimulation combined with low controllability over rewards and losses intensify the maladaptive choice behavior in healthy participants.

The present study compared the following three groups: (1) no manipulation, (2) low controllability and (3) low controllability × pain. The groups will be referred to as the baseline group (BL), the low controllability group (LC) and the combined group (LC-P), respectively. The effect of low controllability or low controllability × pain will be referred to as the effect of LC and as the effect of LC-P, respectively. The experimental groups were manipulated intermittently in a new version of Csifcsák et al. (2020, 2021) modified

orthogonalized Go/NoGo reinforcement learning task. As opposed to Csifcsák et al. (2020, 2021), the present task consisted of five trial blocks, in which block 2 and 4 were manipulation blocks. Figure 1 shows the structure of the task for each group.

Figure 1

The Structure of The Reinforcement Learning Task and Manipulations



Note. The figure shows the structure of the present reinforcement learning task. The BL group received no manipulations. The LC and LC-P groups received manipulations in block 2 and 4. Blocks 1, 3 and 5 were identical between the three groups.

Hypotheses

Perceived Success and Perceived Control. In line with the studies of Csifcsák et al. (2020, 2021), we included a direct measurement of perceived control and perceived success. We expected (H2a) that the subjective ratings of perceived level of control and success scores would vary between groups (H1b) with LC group rating lower than BL, and (H1c) LC-P group rating lower than LC in manipulated blocks. In addition, we expected (H1d) a transfer

effect (from manipulation blocks to standard blocks) in both manipulation groups (H1d) with a stronger transfer effect in LC-P group.

Response Accuracy. We expected (H2a) a decrease in response accuracy on Pavlovian-incongruent cards (Go-to-Avoid-Losing and NoGo-to-Win) compared to Pavlovian-congruent cards (Go-to-Win and NoGo-to-Avoid-Losing) in all groups; (H2b) an augmented decrease in response accuracy in LC, relative to BL and (H2c) an augmented decrease in response accuracy in LC-P, relative to LC in manipulated blocks. In addition, we expected (H2d) a transfer effect (from manipulation blocks to standard blocks) in both manipulation groups (H2e) with a stronger transfer effect in LC-P.

Pavlovian Performance Bias

We expected (H3a) that relative to the BL group, Pavlovian bias would be increased in manipulated groups with (H3b) an augmented decrease in LC-P relative to LC group; (H3c) that changes in Pavlovian bias relative to the BL group in general will be stronger for LC-P than for LC, and (H3d) a transfer effect (from manipulation blocks to standard blocks) in both manipulation groups (H3e) with a stronger effect in LC-P.

Method

Participants

A total of 100 Norwegian-speaking adults (intended and achieved sample size) were randomly assigned to one of the four conditions with $n = 25$ per group. The sample size ($N = 100$) was determined with a priori power analysis (G*Power, version 3.1.9.2) with a mild-to-moderate estimated effect size of $f^2 = 0.15$ (for repeated-measures ANOVA), statistical power of 90% and Type I error of 5% ($\alpha = .05$). Even though the current study involved four experimental groups, a sample of 75 participants (54 female, age: $M \pm SD = 21.9 \pm 2.5$, age range: 19 - 29, 67 right-handed) was analyzed on the basis of the present study's relevant

hypotheses with $n = 25$ per group. Participant's demographic data such as age, gender and handedness were collected.

A recruitment flyer was physically distributed throughout the university campus and digitally shared on the university's social media groups and through UiT administration. The flyer reported that (1) it was a study about decision-making and pain, and that (2) participants were guaranteed a 300 NOK gift card at Jekta (a local shopping mall) upon experiment completion with a 100 NOK bonus in the case of exceptional performance. A written information document was sent out upon participants´ contact or presented in front of them upon arrival (see Appendix A). The information form included inclusion criteria, procedure, safety measures, participant´s rights and informal consent which was approved by the regional ethics committee (REK-Nord reference number: 284408). Participants who self-reported that they met the inclusion criteria (no history of psychiatric/neurological or chronic pain disorders, not under the influence of psychotropics, analgetic substances and drugs modulating activity of the central nervous system, good or corrected eyesight, sufficient sleep in the preceding night, no previous experience with our card game) signed up for the experiment upon agreed day and time. Upon experiment day, participants were required to confirm their inclusion criteria fitness, sign informal consent and fill out their demographics before proceeding with study participation.

Participants were informed that they will be required to play a computer-based card game, as well as to complete some questionnaires about mood and personality. Participants were naïve about the experiment's underlying hypotheses and to which experimental group they were assigned to, but they were informed that they can be assigned to either a group with pain stimulation or a group with warm stimulation. For the controllability manipulations, the randomization process was double-blinded so that neither the experimenter nor the participant was aware of participant's group membership. Even though the participants were informed

that they will receive a 400 NOK gift card in case of exceptional performance, every participant received a 400 NOK gift card irrespective of performance. Based on our experimental protocol, each participant got debriefing after experiment completion. The experimenters (1) reported whether they belonged to a group with pain or warm stimulation and their mean pain tolerance, (2) asked whether some of the card game blocks were experienced as more difficult than the others without specifying which ones, (3) reported that we looked at how they react to unpredictable outcomes based on the notion that life is unpredictable. Lastly, we reassured them that if they did not experience mastering the game, it was not their fault, but rather caused by the manipulation they were exposed to.

Design

The present study followed a between-subjects design where each participant was randomly assigned to one of the four conditions. However, in respect to the present study's hypotheses, our statistical analysis did not include a group which received pain stimulation and had control throughout the whole task. Therefore, we compared three groups, BL, LC and LC-P.

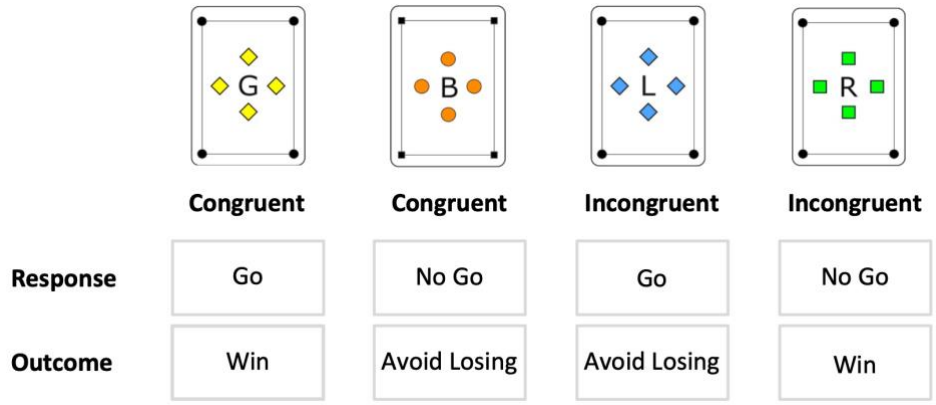
Reinforcement Learning Task

The present study used a modified version of the orthogonalized Go/NoGo reinforcement learning task (RL) camouflaged as a computerized card game. The task was specifically used to detect the dynamic choice behavior involving action and valence (approach and avoid behaviors in terms of reward and loss). It consisted of five blocks with four cards in each, where each card differed in terms of response-outcome associations with response of Go/NoGo and outcome Win/Avoid-Losing (see Figure 2). Go-to-Win and NoGo-to-Avoid-Losing cards are in line with the Pavlovian system and are Pavlovian-congruent cards. They represent a link between action and valence, that is, approach behavior towards reward and avoid behavior towards punishment, and therefore both the Pavlovian system and

the instrumental system facilitate learning and the optimalization of performance for these cards (Guitart-Masip et al., 2014). Go-to-Avoid-Losing and NoGo-to-Win cards are Pavlovian incongruent cards and are in line with the instrumental valuation system, but conflict with the Pavlovian system, and therefore, they are associated with slower learning and worse response accuracy (Guitart-Masip et al., 2014). The RL task involved learning via feedback which responses were correct in order to attain favorable outcomes, that is to win points (10) and to not lose points (0), and avoid unfavorable outcomes, that is to not win points (0) and to lose points (-10).

Figure 2

Response-Outcome Associations in Pavlovian Congruent and Incongruent Trials



Note. Each card trial differed in terms of response-outcomes associations of response Go/NoGo and outcome Win/Avoid-Losing. For two card types, response requirements were congruent with Pavlovian system, whereas two cards were Pavlovian incongruent and respectively impose Pavlovian conflict.

Manipulations

In order to induce loss of control associated with helplessness in the LC and LC-P groups, the performance on the RL task was manipulated by response-feedback contingency and favorable/unfavorable feedback frequency. In manipulation blocks 2 and 4, LC and LC-P

groups had 0% control over outcomes as feedbacks were presented randomly, irrespective of responses, which made it difficult to learn contingency between response and outcome according to instrumental trial-by-trial principle. Even though the outcomes were presented in a random order in the manipulation blocks, the occurrence of favorable/unfavorable outcomes was set to 30/70%. This translates to a 30% probability to win (10) and 70% probability to not win (0) for Win cards and 30% to not lose (0) and 70% to lose (-10) for Avoid cards. Conversely, the task difficulty for BL group in all five blocks was set to be in line with Cavanagh et al. (2013). The BL group had 70% control over outcomes throughout the whole task which made it possible to learn contingency between response and outcome. Occurrence of favorable/unfavorable outcomes was set to 70/30% with a 70% probability to win (10) and not lose (0) and 30% probability to not win (0) and lose (-10). For the manipulated groups, in blocks 1, 3 and 5 the task difficulty was set to the same level as for the BL group.

In order to induce pain, the performance on the task was manipulated by thermal stimulation. All groups received thermal stimulation of varying intensity in manipulation blocks of the RL task. The BL and LC group received non-painful to mild stimulation at a fixed temperature of 42 ºC since 43 ºC is considered to be the lowest heat pain threshold (Arendt-Nielsen & Chen, 2003). The LC-P group received pain stimulation within 44 ºC and 46.5 ºC depending on participants´ individual mean pain tolerance estimates. According to our pain protocol the pain stimulation was developed to be moderately painful.

Measures

The measure variables included (1) Positive Affect and Negative Affect Schedule (PANAS) mood questionnaire, (2) Behavioral Inhibition System/Behavioral Approach System (BIS/BAS) personality questionnaire, (3) Beck's Hopelessness Scale (BHS) personality questionnaire, (4) Need for Cognition (NFC) personality questionnaire, (3) visual

analog scale (VAS) measuring perceived success, perceived control and perceived pain, (4) response accuracy and (5) Pavlovian performance bias (PPB).

Psychological Scales and Questionnaires. The PANAS consisted of the PANAS-Positive and PANAS-Negative subscales (Tran, 2013) and measured the past month and present pre- and post-task positive and negative affective states. The BIS/BAS consisted of the BAS-Drive, BAS-Fun Seeking, BAS-Reward Responsiveness and BIS subscales measuring personality attitudes towards approach versus inhibition behaviors in attractive and aversive contexts (Rajchert, 2017). The BHS measured a tendency for negative beliefs and expectations about the future (Rabon & Hirsch, 2017), while the NFC measured an individual's interest to engage in tasks and thought processes that are cognitively effortful (Bauer & Stiner, 2020). The questionnaires were only included to get an overview of mood and personality on group level, therefore they will not be discussed in depth.

Within the RL task, the perceived control and success were measured at the end of each block, and perceived pain was measured at the end of blocks 2 and 4. Perceived control, success and mean and peak pain were rated from 0 to 100 on a Visual Analog Scale (VAS) upon provided questions, asking (1) how successful you felt your performance was during the card game, (2) how much control you felt you had during the card game, (3) what was your mean level of pain and (4) what was your peak level of pain.

Response Accuracy and PPB. Response accuracy and PPB were measured within the task. Response accuracy was quantified as the proportion of correct responses, and was measured for each participant, card type and block separately (Csifcsák et al., 2020). PPB involved an extensive tendency to respond according to the Pavlovian valuation system, that is, to Go on Win trials and to NoGo on Avoid trials (Cavanagh et al., 2013). PPB was calculated as the mean of the two indices: the Reward-Based Invigoration (RBI) index represents approach behavior towards reward-predictive stimuli, and the Punishment-Based

Suppression (PBS) index represents behavioral passivity to loss-associated stimuli. RBI was quantified as a total number of Go responses on Win trials relative to the total number of Go response on all trials, and conversely, PBS was quantified as a total number of NoGo responses on Avoid trials relative to the total number of NoGo response on all trials (Cavanagh et al., 2013; Csifcsák et al., 2020). Index values varied between 0 and 1 with high values representing strong PPB.

Procedure

The experiment was conducted in a darkened, sound-isolated room in a laboratory at the Institute of Psychology, The Arctic University of Tromsø (UiT). The experiment lasted between 90 and 120 minutes. Each participant chronologically completed (1) the PANAS-Past and PANAS-Present (pre-task), (2) the estimation of mean pain tolerance, (3) the acquisition of card game rules with a short trial block and quiz, (4) the RL task, and (5) PANAS-Present (post-task), BIS/BAS, BHC and NFC. See Appendix B for personality and mood questionnaires.

Estimation of Mean Pain Tolerance

The individual mean pain tolerance of each participant was assessed by pre-calibrated "method of limits" (Arendt-Nielsen & Chen, 2003) using the PATHWAY model CHEPS (Contact Heat Evoked Potential Stimulator) (Medoc, n.d.). The procedure consisted of eight series of gradual temperature increases until participants' manual button press, thereafter returning to the baseline. The heat stimulator was placed in direct contact with the surface of participants' dominant arm, at least 3 cm proximal to the wrist and strapped on according to their feedback on tightness and comfort. The VAS of pain (see Appendix C) was presented, and the experimenter instructed the participants to "Press when the pain becomes so extremely painful you want it to stop". The participants were required to press one of the two buttons of their choice on a computer mouse with their non-dominant hand when the pain

from the heat was subjectively unbearable. The gradual temperature increase started at the baseline of 32 ºC and gradually increased with a 0.5 ºC/s rate. The pre-calibrated limit temperature was set to 51.5 ºC. Upon the button press, the temperature immediately decreased at a 1 ºC/s rate until it returned to the baseline. In total eight estimates were collected with an interstimulus interval of 15 s.

In a situation where the participants did not press before or at the limit temperature, the machine terminated stimulation and paused the trials. The experimenter left the room to initiate the procedure and monitored the participant only on the first trial following with feedback. The participants were then left alone to complete all seven trials while the door was open. We also provided an emergency button that they were to press if the system did not react to the mouse press (the emergency button was never used). Lastly, the collected estimates were used to calculate the mean estimate of each participant's pain tolerance. The first and second estimates were removed in order to avoid skewness due to novelty of the stimulus. The third, fourth, fifth, sixth, seventh and eighth estimates were then summed together and divided by six to get a mean estimate.

Acquisition of The Card Game Rules

The participants were required to read and understand the card game rules. They were informed that (1) their task was to play a card game and collect as many points as possible, (2) there were five blocks (series), each had a set of four different cards, (3) there was a new set of cards in each block with no relationship between the blocks, so they needed to build a new strategy each block, (4) two cards were winning and two cards were losing, (5) their task was to explore and to learn which cards to "pick" and "not to pick" in order to win and to avoid losing points, (6) each card could give 10 (win), 0 (neutral no win/no lose) or -10 (lose) points following the response to a card, and (7) the outcomes were probabilistic and therefore not guaranteed in few cases.

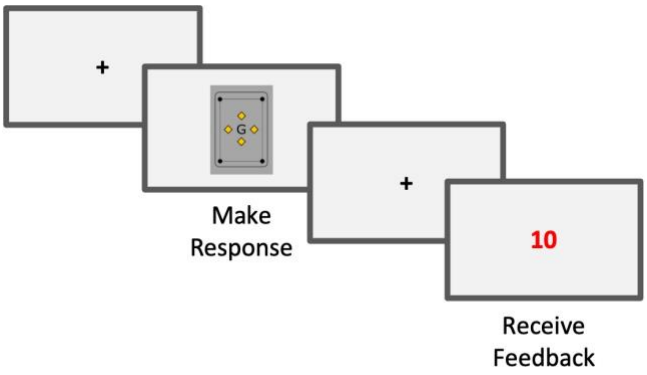
Following this, participants were required to complete a trial block to familiarize themselves with the task. The four cards in the trial block were monochrome but differentiated by a symbol-letter combination. The trial block consisted of 20 trials (lasting for 4 min). Following the completion of the trial block participants were asked to rate their control and success. Lastly, participants were given a quiz (see Appendix D) to integrate the card game premises and to reassure the experimenter that the premises were understood. In case of wrong answer, the experimenter contributed to the right answer.

RL

Participants were required to learn by trial-and-error to couple stimulus cards with proper responses by feedback following the response. For each block there was a new set of cards with new response-feedback associations. The task consisted of five blocks, with 80 trials in each block (lasting for 7.5 min) with 20 trials of each of the four cards. Each of the four cards had one symbol with one corresponding color and one corresponding letter (as seen in Figure 2). Each trial was presented on the screen as follows: fixation cross presented for 1 s, card presented for 2 s, a delay screen (fixation cross) presented for 1 s and feedback presented for 1 s. Figure 3 shows the order of events within one trial. Both fixation screens served as a cue for the stimulus card and response feedback, respectively. Participants were required to either press or withhold pressing a SPACE-bar on the computer keyboard upon the presented stimulus card. Pressing the SPACE-bar or not was framed as their intention to either “pick up” the card, or “leave it on the table”. At the end of each block participants were asked to rate their perceived control, success and pain. Participants had no time pressure when it comes to VAS-ratings.

Figure 3

Order of Events in One Trial



Note. The figure show the order of events within one trial and how it was visually presented on the screen. One trial consisted of appearance of stimulus cue, stimulus, feedback cue and feedback. Upon stimulus, participants were required to respond or withhold from responding. The feedback followed after feedback cue.

Thermal Stimulation During RL

The heat stimulator was present in all five blocks on participants' skin on their non-dominant inside forearm (between the wrist and elbow). Since there were two blocks with thermal induction, we used two different positions on participant´s forearm to eliminate desensitization to heat and skin irritation. The positions were counterbalanced between participants. The experimenter measured 3 cm and 11 cm above their wrist resulting in proximal (close to the wrist) and distal (far from the wrist) positions respectively. The heat stimulator was firstly placed either on proximal position or distal position before block 1. Temperature was kept at baseline (32 ºC) in blocks 1, 3 and 5. Pain or warm stimulation was induced in blocks 2 and 4 (lasting for 8 min in each block). After block 2 and before block 3, the heat stimulator was placed on the opposite position relative to the first position. In block 5, the heat stimulator was kept on the same position as in block 3 and 4.

Participants assigned to the LC-P group were induced with heat pain of moderate intensity with temperature within 44 ºC and 46.5 ºC. The stimulation temperature was determined based on the participant´s mean estimate of pain tolerance level minus 2 ºC. In

some cases, the pain protocol deviated because some participants had high to extremely high pain tolerances, therefore we exclusively used the maximum pain induction temperature of 46.5 ºC. Participants who were assigned to the warm group were induced with a temperature of mild intensity of 42 ºC. As a safety measure, the experimenter left the door open to the experiment room during block 2 and 4 in case participants felt discomfort. Participants were informed about an emergency button which could be pressed in order to terminate stimulation completely during stimulation blocks.

Preliminary Data Analysis

With respect to task performance, we did not consider exclusion, as both options of response and no response were possible in the present Go/NoGo task. As for the reported pain levels, we verified that pain ratings in the warm vs pain groups differed significantly (see Table 2), therefore we did not consider excluding anyone. In addition, we chose to conduct an exploratory analysis where we replaced the grouping factor (warm vs pain) with the mean of mean pain ratings provided after both thermal stimulation blocks as covariate since there were participants reporting moderate to strong pain in the warm group, and mild pain in the pain group. Based on that, we chose to not exclude participants with outlier responses to avoid losing statistical power.

Statistical Analysis

Separate repeated-measures ANOVAs were conducted for PANAS-Present Positive, PANAS-Present Negative, perceived control, perceived success, pain ratings, response accuracy, PPB raw values and PPB relative values. For all these measures Group was used as a between-subject factor comparing BL, LC and LC-P groups. As for the within-subjects factors (1) Time (pre-task vs post-task) was set for PANAS-Present Positive and Negative, separately; (2) Block (1-5) was set for perceived success and perceived control, separately; (3) Block (2 and 4) was set for mean pain and peak pain ratings, separately; (4) Block (1-5),

Congruency (Pavlovian-congruent cards vs Pavlovian-incongruent cards) and Valence (Win vs Avoid cards) were set for response accuracy; (5) Block (1-5) and Index (RBI vs PBS) were set for PPB calculated raw values; (5) Block (2-5) and Index (RBI vs PBS) were set for the PPB calculated relative values. PPB relative values were standardized PPB values for blocks 2-5 to reflect change in PPB relative to block 1.

Separate one-way ANOVAs with Bonferroni-adjusted $\alpha = .01$ were run for perceived control, perceived success and response accuracy when there was a significant two-way BLOCK×GROUP interaction. Adjusted Bonferroni $\alpha = .01$ was used in order to avoid Type 1 error (conducting three tests) (Field, 2018, p. 83). Upon significance, Bonferroni pairwise comparisons were run between groups. Difference between groups were considered as significant under $\alpha = .05$ (adjusted).

Separate one-way ANOVAs were conducted for PANAS-Past Positive, PANAS-Past Negative, BIS/BAS, BHS and NFC. For all these measures Group was used as fixed factor comparing BL, LC and LC-P groups. For BIS/BAS, we run four separate one-way ANOVAs for each subscale (BAS-D, BAS-R, BAS-F and BIS).

Additionally, we calculated the mean of the two mean pain rating for each participant and conducted a separate repeated measures ANOVA for response accuracy and PPB with the mean of mean pain as covariate. Instead of Group (BL vs LC vs LC-P), we used Controllability (non-manipulated vs manipulated with low controllability) as the between-subjects factor.

The present study was especially interested in Group, the critical interaction between within- and between-subjects factors Block × Group and other interactions with Group. For all the measures (except separate one-way ANOVAs with Bonferroni-adjusted $\alpha = .01$) results were considered as significant under $\alpha = .05$. Whenever there was a violation of sphericity assumption in Mauchly's test of sphericity in repeated-measures ANOVA,

Greenhouse-Geisser corrected degrees of freedom and *p*-values with corresponding *ε*-values were reported. As for effect size, η_p^2 was reported. JASP (Version 0.16.1; JASP Team, 2022) was used as a statical software for the present analysis.

Results

Mood and Personality Questionnaires

PANAS Pre-Task vs Post-Task

There was a significant main effect of Time on positive mood, $F(1,72) = 8.31$, $p = .005$, $\eta_p^2 = .103$, as well as on negative mood, $F(1,72) = 5.63$, $p = .020$, $\eta_p^2 = .073$, with a decrease in both positive and negative mood after the task compared to before the task ($M_{diff\_Positive} = 1.93$, $SE_{Positive} = 0.67$; $M_{diff\_Negative} = 0.95$, $SE_{Negative} = 0.40$). There was no main effect of Group on positive mood, $F(2,72) = 0.48$, $p = .624$, $\eta_p^2 = .013$, nor on negative mood, $F(2,72) = 0.64$, $p = .529$, $\eta_p^2 = .018$, indicating no differences between groups and no effect of LC or LC-P on mood. There was not found a significant interaction of Time × Group on positive mood, $F(2,72) = 0.09$, $p = .916$, $\eta_p^2 = .002$, nor on negative mood, $F(2,72) = 0.75$, $p = .475$, $\eta_p^2 = .020$, indicating no group differences in mood before and after the task.

PANAS-Past, BIS/BAS, BHS and NFC

Descriptives for PANAS-Past Positive, PANAS-Past Negative, BIS/BAS, BHS and NFC were presented in Table 1. We were missing data on BAS-D, BAS-F and BIS for one LC-P participant ($n = 24$), and for two LC-P participants ($n = 23$) on BAS-R as represented in degrees of freedom in Table 1. The results indicated that responses on PANAS-Past Positive and Negative, each BAS subscale, BIS, BHS and NFC questionnaires did not differ on group level, meaning that we had a homogenous sample when it comes to past mood and personality traits related to Pavlovian bias tendencies.

Table 1

Means, Standard Deviations, and One-Way ANOVA in Mood and Personality Questionnaires

Group	BL		LC		LC-P		*F*	*df*	*p*	η_p^2
	M	*SD*	*M*	*SD*	*M*	*SD*				
PANAS-Past Pos	30.60	5.32	30.72	6.24	31.46	5	0.18	2,72	.838	.005
PANAS-Past Neg	17	3.45	17.96	4.47	17.66	4.70	0.34	2,72	.716	.009
BIS/BAS										
BAS-D	11	2.60	10.24	2.13	10.5	2.11	0.71	2,71	.495	.020
BAS-F	12.72	2.25	12.52	2.14	12.33	2.20	0.19	2,71	.827	.005
BAS-R	16.52	2.93	16.20	2.47	16.39	2.68	0.09	2,70	.915	.003
BIS	19.84	3.77	20.64	4.04	21.25	4.44	0.74	2,71	.483	.020
BHS	3.44	1.71	4.32	3.42	5.20	3.73	2.03	2,72	.138	.053
NFC	63.80	8.68	59.60	8.03	60.36	13.37	1.18	2,72	.313	.032

Note. $n = 25$ for each group except BAS-D, BAS-F, BIS and BAS-R. PANAS-Past Pos = PANAS-Past Positive; PANAS-Past Neg = PANAS-Past Negative; BIS/BAS = Behavioral Inhibition System/Behavioral Activation System; BAS-D = BAS-Drive; BAS-F = BAS-Fun Seeking; BAS-R = BAS-Reward Responsiveness; BHS = Beck´s Hopelessness Scale; NFC = Need for Cognition. ANOVA = analysis of variance.

Self-Reports by VAS

Perceived Control

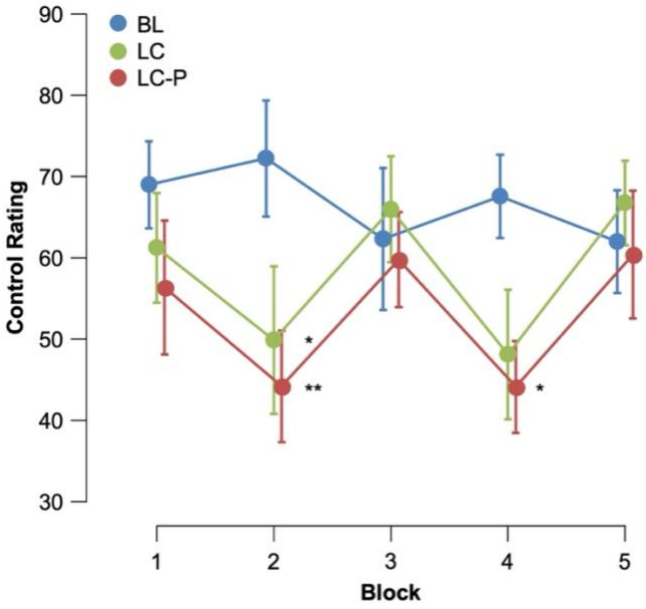
There was a non-significant main effect of Group on perceived control, $F(2,72) = 2.38$, $p = .100$, $\eta_p^2 = .062$. However, we found a significant main effect of Block, $F(3.54, 254.74) = 5.63$, $p < .001$ $\varepsilon = .89$, $\eta_p^2 = .073$, and a significant two-way interaction Block × Group, $F(7.08, 254.74) = 4.45$, $p < .001$, $\eta_p^2 = .110$.

Five separate one-way ANOVAs were run to further investigate the Block × Group interaction with Bonferroni-adjusted $\alpha = .01$. There was a significant main effect of Group in block 2, $F(2, 72) = 7.00$, $p = .002$, $\eta_p^2 = .163$, and a tendency for significant in block 4, $F(2,$

72) = 4.61, p = .013, η_p^2 = .113. In block 2, a Bonferroni post-hoc showed a significant difference in perceived control between BL and LC, p = .019 (M_{diff} = 22.36, SE = 7.93), and between BL and LC-P, p = .002 (M_{diff} = 28.04, SE = 7.93). In block 4, a Bonferroni post-hoc showed a significant difference in perceived control between BL and LC-P group, p = .018 (M_{diff} = 23.44, SE = 8.26). See Figure 4 for descriptive plots of Block × Group interaction for perceived control ratings.

Figure 4

Perceived Control Ratings Between Groups Across Five Blocks



Note. Rating pattern of perceived control in each block for each group measured in %. Asterisks represent significant differences in perceived control relative to the BL group. Error bars represent 95% CI.

$^{*}p < .05$. $^{**}p < .01$.

Perceived Success

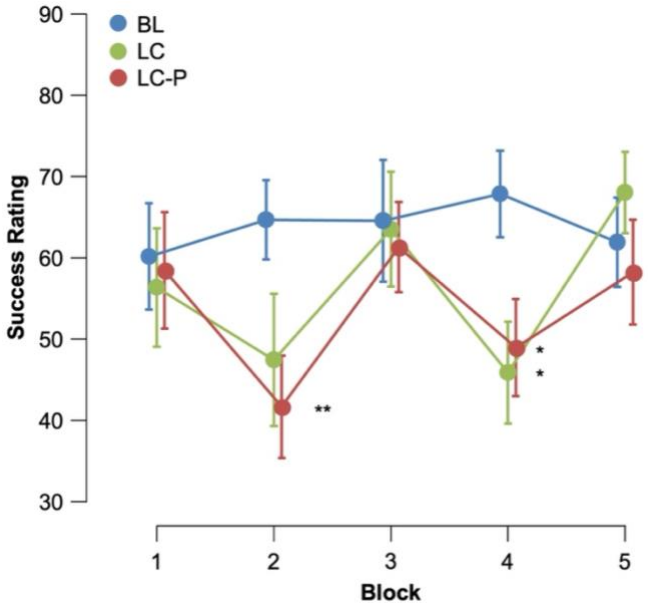
There was a non-significant main effect of Group on perceived success, F(2,72) = 1.63, p = .204, η_p^2 = .028. However, there was a significant main effect of Block, F(4, 288) =

8.46, $p < .001$, $\eta_p^2 = .033$, and a significant two-way interaction of Block × Group, $F(8, 288) = 4.62$, $p < .001$, $\eta_p^2 = .036$.

Five separate one-way ANOVAs were run to further investigate the Block × Group interaction with Bonferroni-adjusted $\alpha = .01$. There was a significant main effect of Group in block 2, $F(2, 72) = 5.20$, $p = .008$, $\eta_p^2 = .126$, and in block 4, $F(2, 72) = 4.93$, $p = .010$, $\eta_p^2 = .121$. In block 2, a Bonferroni post-hoc showed a significant difference in perceived success between BL and LC-P groups, $p = .008$ ($M_{diff} = 23$, $SE = 7.43$). In block 4, a Bonferroni post-hoc showed a significant difference in perceived success between BL and LC, $p = .015$ ($M_{diff} = 22$, $SE = 7.59$), and between BL and LC-P groups, $p = .045$ ($M_{diff} = 18.92$, $SE = 7.59$). See Figure 5 for descriptive plots of Block × Group interaction for perceived success ratings.

Figure 5

Perceived Success Ratings Between Groups across Five Blocks



Note. Rating pattern of perceived success in each block for each group measured in %. Asterisks represent significant differences in perceived success relative to the BL group. Error bars represent 95% CI.

$^{*}p < .05$. $^{**}p < .01$.

Pain Ratings

Mean Pain. There was a significant main effect of Group on mean pain ratings, $F(2, 72) = 35.91$, $p < .001$, $\eta_p^2 = .499$. A Bonferroni post-hoc showed significant differences in mean pain ratings between BL and LC-P groups, $p < .001$ ($M_{diff} = -34.00$, $SE = 4.99$), and between LC and LC-P groups, $p < .001$ ($M_{diff} = -38.80$, $SE = 4.99$). No differences were found between groups receiving warm stimulation (BL and LC), $p = 1.000$ ($M_{diff} = 4.80$, $SE = 4.99$). There was a non-significant main effect of Block, $F(1, 72) = 0.02$, $p = .897$, $\eta_p^2 = <.001$, and a non-significant Block × Group interaction, $F(2, 72) = 0.81$, $p = .449$, $\eta_p^2 = .022$, indicating that the mean pain values did not differ between manipulation blocks nor between manipulation blocks between groups.

Peak Pain. There was a significant main effect of Group on peak pain ratings, $F(2, 72) = 24.22$, $p < .001$, $\eta_p^2 = .402$. A Bonferroni post-hoc showed significant differences in mean pain ratings between BL and LC-P groups, $p < .001$ ($M_{diff} = -31.14$, $SE = 5.74$), and between LC and LC-P groups, $p < .001$ ($M_{diff} = -37.26$, $SE = 5.74$). No differences were found between groups receiving warm stimulation (BL and LC), $p = .870$ ($M_{diff} = 6.12$, $SE = 5.74$). There was a non-significant main effect of Block, $F(1, 72) = 0.818$, $p = .369$, $\eta_p^2 = .011$, and a non-significant Block × Group interaction, $F(2, 72) = 1.48$, $p = .236$, $\eta_p^2 = .039$, indicating that the peak pain values did not differ between manipulation blocks nor between manipulation blocks between groups. See Table 2 for a total overview over the descriptive mean and peak pain ratings.

Table 2

Means and Standard Deviations of Mean and Peak Pain Ratings

Group	BL		LC		LC-P	
	M	*SD*	*M*	*SD*	*M*	*SD*
Mean pain						

Block 2	26.32	21.23	20.08	20.57	57.12	18.65
Block 4	22.96	21.04	19.60	18.44	60.16	18.44
Peak pain						
Block 2	32.76	24.28	24.20	22.12	59.44	22.01
Block 4	30.08	24.63	26.40	19.23	65.68	20.99

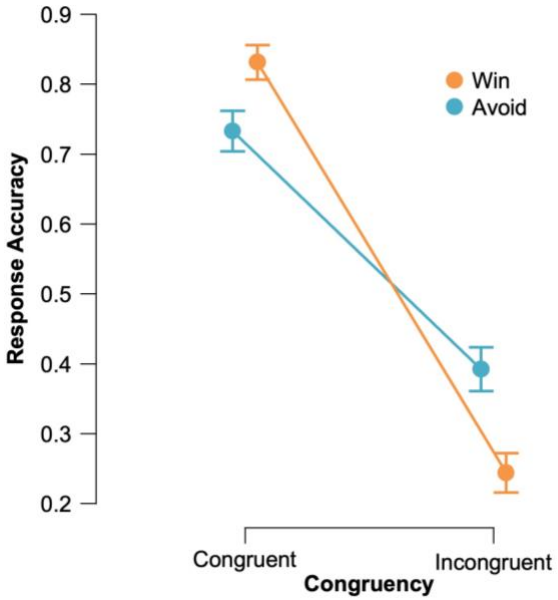
Note. $n = 25$ for each group. Values were measured in %.

Response Accuracy

There was a significant main effect of Congruency on accuracy, $F(1,72) = 145.54$, $p < .001$, $\eta_p^2 = .669$, indicating more correct responses to Pavlovian-congruent compared to Pavlovian-incongruent cards ($M_{diff} = 0.46$, $SE = 0.04$). There was a significant main effect of Valence, $F(1,72) = 9.37$, $p = .003$, $\eta_p^2 = .115$, indicating a greater tendency for correct responses to Avoid than to Win cards ($M_{diff} = 0.03$, $SE = 0.01$). These findings were also reflected in a significant two-way Valence × Congruency interaction, $F(1,72) = 27.35$, $p < .001$, $\eta_p^2 = .275$. A Bonferroni post-hoc showed that accuracy differed between all card types, Go-to-Win (win-congruent), NoGo-to-Avoid Losing (avoid-congruent), Go-to-Avoid Losing (avoid-incongruent) and NoGo-to-Win (win-incongruent) with all Bonferroni *p*-values of $p < .001$. This finding indicates that the response accuracy differed depending on the valence of the card type and its associated response, and that the cards were indeed unique and the response accuracy towards each was different. In addition, Figure 6 showed highest proportion of correct responses in Go-to-Win trials and the lowest proportion of correct responses in NoGo-to-Win trials, indicating a larger conflict for Win cards with NoGo-to-Win trials being the most difficult. There was a non-significant two-way interaction of Congruency × Group, $F(2,72) = 0.06$, $p = .943$, $\eta_p^2 = .002$, as well as a three-way interaction of Block × Congruency × Group, $F(5.92, 213.12) = 0.72$, $p = .631$, $\eta_p^2 = .020$.

Figure 6

Response Accuracy in Valence and Congruency Interaction



Note. Response accuracy for Pavlovian-congruent Go-to-Win and NoGo-to-Avoid-Losing cards, and Pavlovian-incongruent Go-to-Avoid-Losing and NoGo-to-Win cards. Error bars represent 95% CI.

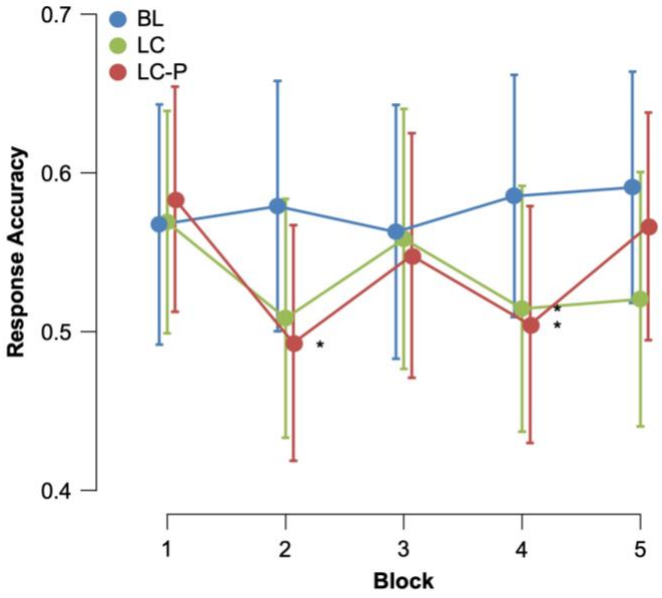
There was a non-significant main effect of Group, $F(2,72) = 2.17$, $p = .122$, $\eta_p^2 = .057$. However, there was a significant main effect of Block, $F(3.37, 242.30) = 4.02$, $p = .006$, $\varepsilon = .84$, $\eta_p^2 = .053$, and a significant two-way interaction of Block × Group, $F(6.73, 242.30) = 2.52$, $p = .017$, $\eta_p^2 = .065$.

Five separate one-way ANOVAs were run to further investigate the Block × Group interaction, with Bonferroni-adjusted $\alpha = .01$. There was a significant main effect of Group in block 2, $F(2, 72) = 4.97$, $p = .009$, $\eta_p^2 = .121$. A Bonferroni post-hoc showed a significant difference between BL and LC-P, $p = .013$ ($M_{diff} = 0.09$, $SE = 0.03$). No differences in accuracy were found between BL and LC, $p = .053$ ($M_{diff} = 0.07$, $SE = 0.03$), and between the experimental groups (LC vs LC-P), $p = 1.00$ ($M_{diff} = 0.02$, $SE = 0.03$). There was a significant main effect of Group in block 4, $F(2, 72) = 5.24$, $p = .007$, $\eta_p^2 = .127$. A post-hoc Bonferroni showed differences in accuracy between BL and LC, $p = .034$ ($M_{diff} = 0.07$, $SE = 0.03$) and

between BL and LC-P, $p = .012$ ($M_{diff} = 0.07$, $SE = 0.03$). No group differences were found between the experimental groups, $p = 1.000$ ($M_{diff} = 0.01$, $SE = 0.03$). See Figure 7 for descriptive plots of Block × Group interaction for response accuracy.

Figure 7

Response Accuracy Between Groups Across Five Blocks



Note. Pattern of response accuracy in each block for each group. Asterisks represent significant differences in response accuracy relative to the BL group. Error bars represent 95% CI.

$^{*}p < .05$.

Lastly, since LC and LC-P groups did not differ in response accuracy, meaning that pain did not have an effect, we further investigated whether pain (mean of mean pain ratings) instead served as a covariate. A separate repeated-measures ANOVA was performed where instead of Group (BL vs LC vs LC-P) as the between-subject factor, we put Controllability as the between-subject factor. There was a non-significant covariate effect on response accuracy, $F(1,72) = 0.11$, $p = .737$, $\eta_p^2 = .002$, and a non-significant main effect of Controllability, $F(1,72) = 3.58$, $p = .063$, $\eta_p^2 = .047$. These results indicate that there was no difference

between control and low controllability (independent of pain) groups in response accuracy when controlling for pain, contributing to the previously provided evidence on response accuracy, that pain did not significantly affect the LC-P group.

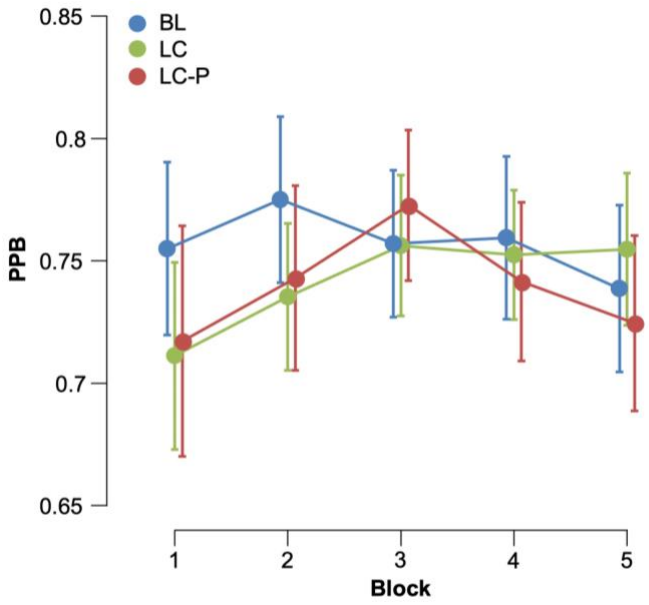
Pavlovian Performance Bias

PPB raw values

There was no significant main effect of Group on PPB, $F(2,72) = 0.08$, $p = .924$, $\eta_p^2 = .002$, nor Block, $F(2.98, 214.76) = 1.40$, $p = .245$, $\varepsilon = 0.75$, $\eta_p^2 = .019$, and a non-significant critical Block × Group two-way interaction, $F(5.97, 214.76) = 0.66$, $p = .684$, $\eta_p^2 = .018$. These results indicate that present manipulations had no effect on PPB. However, there was a significant main effect of Index, $F(1, 72) = 20.69$, $p < .001$, $\eta_p^2 = .223$, showing higher PBS compared to RBI index scores, ($M_{diff} = 0.052$, $SE = 0.011$). This result indicated that participants had higher Pavlovian bias to cards associated with losses (Avoid cards) than cards associated with gains (Win cards). There was also a significant two-way interaction of Index × Block, $F(3.46, 249.04) = 2.65$, $p = .041$, $\varepsilon = 0.87$, $\eta_p^2 = .036$, but this finding was of no value in respect to the hypotheses. There was no two-way interaction of Index × Group, $F(2,72) = 0.03$, $p = .974$, $\eta_p^2 = <.001$, nor a three-way interaction of Index × Block × Group, $F(6.92, 249.04) = 0.51$, $p = .826$, $\eta_p^2 = .014$. Figure 8 represents the pattern of PPB across five blocks for each group.

Figure 8

Pavlovian Performance Bias Between Groups Across Five Blocks



Note. Pattern of Pavlovian performance bias calculated raw values in each block for each group. PPB = Pavlovian performance bias. Error bars represent 95% CI.

Additionally, since LC and LC-P did not differ in PPB, we investigated whether PPB covaried with pain. Just like for response accuracy, a separate repeated-measures ANOVA was performed where we put Controllability (non-manipulated vs manipulated with low controllability) as the between-subject factor with the mean of mean pain as the covariate. There was a non-significant covariate effect on PPB, $F(1,72) = 0.02$, $p = .885$, $\eta_p^2 = <.001$, and a non-significant main effect of Controllability, $F(1,72) = 0.12$, $p = .735$, $\eta_p^2 = .002$. These results indicate that there was no difference between non-manipulated and low controllability (independent of pain) groups when controlling for pain, and that pain indeed did not significantly affect the LC-P group when it comes to PPB.

PPB relative values

Lastly, since PPB in block 1 differed between groups due to task learning (as seen in Figure 4, and not in the statistical results), we ran an additional analysis for PBB with PPB relative values in order to get an overview over changes in PPB in blocks 2-5 relative to block 1. Results from repeated measures ANOVA with PPB relative values were presented in Table

3. As seen in Table 3, the results for PPB-relative did not drastically differ from PPB. The only detected difference was that the Index × Block two-way interaction, went from significant in PPB to non-significant in PPB-relative, but as mentioned before, this result had no value in respect to our hypotheses. Importantly, there was also a significant main effect of Index, $F(1,72) = 6.37$, $p = .014$, $\eta_p^2 = .081$, showing higher RBI scores compared to PBS index scores ($M_{diff} = -0.028$, $SE = 0.011$). This indicates that after running the analysis with PPB relative values the PBS index was reduced. Figure 9 shows a better representation of change in PPB response pattern as of standardized values for each group in blocks 2 to 5.

Table 3

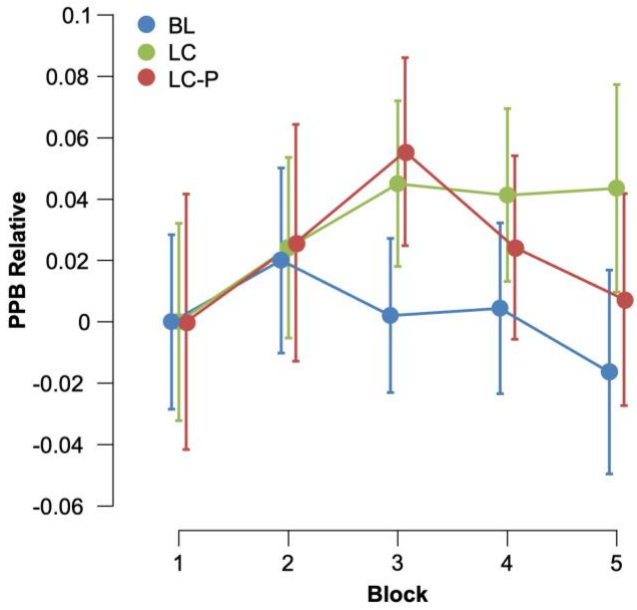
Repeated Measures ANOVA for Pavlovian Performance Bias Calculated Relative Values

ANOVA	*F*	*df*	*p*	η_p^2
PPB-relative				
Group	0.46	2,72	.636	.012
Block	0.89	2.43,175.02	.429	.012
Block × Group	0.80	4.86,175.02	.551	.022
Index	6.37	1,72	.014	.081
Index × Block	0.87	2.60,186.98	.445	.012
Index × Group	0.33	2,72	.720	.009
Index × Block × Group	0.59	5.19,186.98	.711	.016

Note. $N = 75$. PPB = Pavlovian performance bias. ANOVA = analysis of variance.

Figure 9

Pavlovian Performance Bias Between Groups Across Four Blocks



Note. The figure shows a better representation of changes in Pavlovian performance bias as the pattern is presented relative to block 1 for each group across four blocks. PPB = Pavlovian performance bias. Error bars represent 95% CI.

Discussion

The aim of the present study was to investigate whether healthy adults engage in suboptimal value-based decision-making when exposed to a combination of experimental prolonged heat pain stimulation and low controllability over favorable and unfavorable outcomes. Our findings showed that the combined manipulation resulted in minimal effects on how participants arbitrated between the Pavlovian and instrumental decision-making strategies. Although no significant differences were found between the manipulated groups (LC and LC-P) in any measure, pain had a weak yet significant effect on perceived control, perceived success and response accuracy. Nevertheless, the low controllability manipulation which was induced intermittently have not resulted in learned helplessness, as the transfer effects from manipulated to non-manipulated blocks have not been attained in any of the measures. Respectively, add-on prolonged heat pain did not produce or intensified learned helplessness effects.

With respect to personality and mood questionnaires, we had a homogenous sample, meaning that personality and mood did not differ between groups and could not influence the internal results of the present study. Although the PANAS-Present mood questionnaire which measured the present mood before and after the task showed a significant post-task reduction in both positive and negative mood, this finding was not due to the experimental manipulations but rather due to the experimental design and its long and cognitively exhausting task.

Perceived Control, Success and Pain

We predicted lower ratings in both experimental blocks for both perceived success and perceived control in the LC group. Our findings showed that relative to the BL group who had stable control and success ratings throughout the whole task, the LC group reported lower perceived control in block 2 and lower perceived success in block 4. Relative to the LC group, we predicted a stronger effect in LC-P group. The LC-P group reported lower perceived success and lower perceived control in both manipulation blocks. Together, these findings indicate that LC-P had an influence on both measures in both manipulation blocks, contrary to LC which only affected one manipulation block in each measure. Even though, the differences between LC and LC-P were not significant for any measure in any block, the aforementioned results can be regarded as indication that pain amplifies how participants respond to low controllability.

The present results for the mean pain and the peak pain ratings showed that relative to the BL and LC group receiving warm stimulation, the LC-P group which received pain stimulation had significantly higher mean and peak pain ratings. These findings indicate that our pain induction procedure had an effect when it comes to the subjective experience of pain. In the subjective measure of control and success, however, we emphasize that the effect of pain was very weak (LC and LC-P groups did not differ). Therefore, the present results are in

need for replication in order to see whether the current LH-protocol with pain in fact produces effects, even the weak ones. We also suggest that the future research investigate more potent ways of inducing pain in healthy adults.

Neither Csifcsák et al., (2020, 2021) who manipulated response-feedback contingencies, nor Teodorescu and Erev (2014) who manipulated both contingency and reward frequency, found an effect of low controllability on the subjective estimation of control (and success). The results of these studies have been attributed to the illusion of control, a phenomenon prominent in healthy adults (Ly et al., 2019). In contrary, the present study found an effect of low controllability manipulation in self-reported perceived control (and success) as reflected in the statistical results and descriptive plots which showed sudden drops in ratings from standard to manipulated blocks. This finding is of great significance when it comes to subjective ratings of perceived control and has been attained perhaps as a result of non-contingency between response and feedback within the task, and importantly because of manipulation of not only reward but also of loss frequency. As of present controllability manipulations, we managed to eliminate the occurrence of illusion of control within the healthy participants of the present study. Therefore, the provided evidence pointa towards that manipulation of both response-feedback contingencies and reward/loss frequencies has a greater effect on how one perceives their control and success during the task performance.

It is important to note that persistent pain in chronic pain patients is often uncontrollable (it can be reduced but not completely eliminated by medication) and lasts for a longer period of time. In contrary, the present study's pain protocol induced pain that lasted temporary and could be terminated at any time by the participants. In addition, the participants were aware that the pain was intermittent, that is, it would inevitably stop upon block completion. Therefore, it is important to discuss that the pain stimulation might have

been more of a contextual (external) factor, not directly involved in the task and therefore irrelevant to the task itself. What was relevant for the task was the manipulation of controllability and the participants' sensitivity to that manipulation. In contrast, we did not manipulate the extent to which participants could control the pain stimulation. Neither did we directly measure the extent to which they felt they could control the pain they were stimulated with, that is, pain controllability. Based on that, the presented evidence points towards that in our experimental setting, pain tended to not directly influence the estimation of perceived control and success, and that pain was rather a circumstantial factor and non-significant for healthy participants.

The predicted transfer effect in LC and a stronger transfer effect in LC-P groups has not been observed, indicating that our manipulations, which were designed to resemble helplessness, did not influence how participants estimated and subjectively reported control and success in standard blocks. Their estimation of both subjective measures immediately went back to the same level in normal blocks as that of the BL group. These findings can be explained in line with Csifcsák et al. (2020, 2021), that is, the manipulations were not strong enough to produce transfer effects in healthy participants' subjective estimation of control and success. Therefore, future research should develop new methods of inducing learned helplessness in healthy adults in order to diminish their subjective estimation of control (and success). Additionally, on a group level, our total sample consisted of healthy participants as reflected in the low scores in all groups on BHS personality questionnaire. This means that among other things, the tendency to develop the feeling of helplessness was low in our participants. Therefore, we assume that if we recruited participants high on BHS scores, we would see a transfer effect even with the present LH-protocol.

Response Accuracy

We expected in general worse response accuracy on Pavlovian-incongruent trials compared to Pavlovian-congruent trials. In line with our hypothesis, our findings showed that the incongruent trials (Go-to-Avoid-Losing and NoGo-to-Win) were indeed more difficult both in the Win and Avoid domains compared to Pavlovian-congruent trials. In addition, we found that responses were more correct and therefore easiest to Avoid than to Win trials, and that the conflict costs were larger for Win cards, with Go-to-Win trials having the largest proportion of correct responses (therefore easiest) and NoGo-to-Win trials being the most difficult as represented by the lowest proportion of correct responses. All of the aforementioned results were in line with Csifcsák et al. (2020, 2021), Cavanagh et al. (2013) and Guitart-Masip et al. (2012). These findings indicate that our task managed to detect the relationship between action and valence and the Pavlovian-instrumental interaction, just like the previous studies.

Pavlovian incongruent actions in the Win domain (NoGo-to-Win) involves suppressing actions for potential reward. As seen in the present and previous studies, overriding Pavlovian bias is most difficult for rewards. This could be explained by referring to the previous example about the long-term goals. Requirements of achieving a long-term goal involves being able to incorporate cognitive effort in order to override the innate reward-based valence-dependent actions. Evolutionarily, one is prone to ingest reward (e.g. food) when the opportunity for it is there, but the winter season requires rationing the food in order to survive (long-term goal) until the spring. Contrarily, Pavlovian-incongruent actions for aversive stimuli involve initiating an action for potential loss. Sometimes actions have to be initiated for survival, that is, fight instead of flight, while the innate punishment-based valence-dependent actions initiate avoid response (flight) or in the worst-case scenario, complete passivity (freezing). It is important to note that this explanation is speculative as

other studies within VBDM have not provided any explanations as to why overriding Pavlovian bias is most difficult for potential reward.

We expected group differences in response accuracy with the LC group performing worse than the BL group, and LC-P group having worse response accuracy relative to the LC group. Our findings showed that relative to the BL group, LC-P performed worse in both induction blocks, while LC only in block 4. No significant differences were found between the experimental groups in both manipulation blocks, and the subjective mean of mean pain ratings has not been found to covary with the controllability condition. Although the response accuracy worsened in manipulation blocks, this result is not surprising, since it only reflects that the controllability manipulation took place. Such an effect has occurred only because the probability of learning by trial-and-error was zero, meaning that responses produced random outcomes (feedbacks). Despite the aforementioned results, adding pain in the LC-P group seemed to weakly but significantly worsen the response accuracy in both manipulation blocks contrarily to LC. Still, this effect requires to be replicated or amplified by stronger pain induction protocols in future research.

Teodorescu and Erev (2014) provided evidence that non-contingency in addition to sparse and rare reward prevalence facilitates for a transfer effect. In line with that, we predicted that by additionally manipulating loss prevalence, that is, presenting rare reward and frequent punishment in the low controllability condition, would subsequently induce choice behavior resembling helplessness and become transferred to standard blocks. Accordingly, we expected to observe worsened response accuracy in standard blocks in LC group, and a stronger transfer effect in LC-P group. However, no transfer effects were found as both LC and LC-P groups did not differ significantly from the BL group. Interestingly, Figure 6 showed that the LC and LC-P performed almost identically with the BL group in block 3, but

the LC group did not return to the baseline level in block 5. However, the significant effect has not been achieved (non-significant difference between BL and LC).

As seen, the pain stimulation did not significantly influence the response accuracy when it was present (LC-P) compared to when it was absent (LC). However, we cannot state that the pain stimulation had no effect in the present task. We could speculate that the pain was not painful enough, but our findings of the subjective experience of pain showed that pain was over a moderate level. We also mentioned that pain might have been more of a contextual factor with additionally being irrelevant to the task. Nevertheless, in the present study, we tested whether pain in addition to low controllability would worsen response accuracy in manipulation blocks, but we have not tested whether pain stimulation by itself would influence the response accuracy in standard blocks. Therefore, the future experimental designs could in addition to manipulation blocks (regardless of low controllability) apply pain stimulation by the present study's pain protocol in at least one standard block (e.g. block 3). Based on that, we speculate that pain would hinder the response-feedback learning and lead to worsened response accuracy in the standard block. Under such circumstances, a transfer effect might also occur, only not as an effect of LC but as an effect of pain stimulation itself. It would perhaps also be a better model for chronic pain.

Pavlovian Performance Bias

We expected that PPB would be increased in LC and LC-P groups in block 2 and 4. As an effect of these manipulations a transfer effect would occur in both groups in block 3 and 5. Lastly, we expected that relative to the BL group, we would observe changes in PPB for the LC group with an even stronger effect for LC-P.

We did not find differences between groups nor between groups across blocks when it comes to PPB. These findings are not in line with those of previous studies which provided evidence for that low controllability over the environment promotes Pavlovian bias (Dorfman

& Gershman, 2019). Respectively, in line with Csifcsák et al. (2020, 2021) no transfer effect has been found. In the present study, the absence of transfer effect in PPB is in line with the absence of transfer effect in response accuracy. PPB was not influenced in LC nor in LC-P regardless of block, while the response accuracy was inevitably influenced by low controllability (in both LC and LC-P) during the manipulation blocks. Together, these findings indicate uniform biased behavior on group level regardless of manipulation. Therefore, we acknowledge that our current laboratory model of helplessness with and without pain is vaguely capturing aspects of helplessness that develops as a result of real-life experiences in patients with and without persistent pain. In this respect, the translation value of our experimental protocol is very limited.

Although there was no significant effect of Group, Block nor of Group × Block, the visual trend in the PPB relative values (see Figure 9) was as expected for BL and LC groups. For the BL group, relative to block 1, PPB reduced throughout the task. This trend can be explained in line with Csifcsák et al. (2020, 2021), that over time, in this type of task, participants who had sufficient control learned how to suppress maladaptive Pavlovian bias. It was also as expected for the LC group, that relative to block 1, PPB increased throughout the task as seen relative to the BL group. Unexpectedly, this increase has not been observed for LC-P. We expected that relative to block 1, we would observe an increase, or even a stronger increase in PPB for LC-P relative to LC. Such a trend has not been observed, and quite opposite, the Pavlovian bias in LC-P group decreased after block 3 as if participants learned to suppress their bias. To provide an explanation to such a trend is difficult, because even if it was due to the low controllability manipulation, we would observe a similar trend for LC-P as in LC group. A speculative and controversial explanation to that could be that pain played a role, but such an explanation cannot be backed up with the already provided evidence.

Even though there was a uniform Pavlovian bias across groups, there was overall a significant difference between PBS and RBI indexes with a stronger tendency for PPB towards action suppression when facing punishment (NoGo-to-Avoid-Losing trials) (PBS) than towards action invigoration when facing reward (Go-to-Win trials) (RBI). More specifically, PPB in general was stronger in the loss domain (Avoid cards) relative to the gain domain (Win cards) and this result was in line with Csifcsák et al. (2020, 2021). Unlike the present study, authors of the previous studies found an association between low controllability and stronger PPB with as stronger tendency for PBS. However, stronger PBS in their study could be attributed to either the low controllability manipulation that had an aim to resemble learned helplessness effect or to the general behavioral passivity. Since the present study did not find an association between low controllability and PPB as reflected by non-significant differences between the experimental groups and BL and between indices across groups, the present findings cannot be attributed to low controllability, but to the general behavioral passivity that has occurred within the task.

Lastly, Pavlovian bias is about valence-based responding to positive and negative stimuli. The present study´s learned helplessness protocol alone and with add-on prolonged heat pain was too weak to influence the scores on PANAS-Present mood questionnaire as seen in the lack of group differences in post-task positive and negative mood reduction. Presumably, the manipulated groups would significantly differ from the BL group in Pavlovian bias if the present study's manipulations were stronger. In turn, we would perhaps observe a post-task reduction in positive mood and post-task increase in negative mood.

Conclusion

The present study used the new experimental protocol combining thermal pain and low controllability over rewards and losses in order to induce learned helplessness in healthy adults. We predicted that prolonged heat pain, when combined with low controllability over

rewards and losses would lead to a stronger dependence on the low-cost Pavlovian system for choice behavior. Firstly, even though the pain ratings showed that the LC-P group experienced moderate pain intensity, there were no significant differences between the manipulated groups on any of the within-task measurements. Therefore, the future research should find new ways to implement persistent pain into their experimental designs in order to unravel the underlying processes behind value-based decision-making in chronic pain. Secondly, the present learned helplessness protocol managed to influence the subjective estimation of perceived control and perceived success in manipulated groups. Presumably, such effect was attained because of low controllability manipulation, where losses appeared more frequently than rewards. However, decreased ratings were only observed in manipulation blocks and were not transferred to the following non-manipulated blocks. Thirdly, the direct effects of manipulations and the transfer effect has not been attained in our critical within-task measurements of response accuracy and Pavlovian performance bias. Together, these findings indicate that at the group level, participants exerted uniform motivational bias throughout the whole task regardless of manipulation.

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Appendix A

Information Form for Participants

VIL DU DELTA I FORSKNINGSPROSJEKTET – *«Om eksperimentell smerte påvirker beslutningstaking hos friske voksne»*?

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FORMÅLET MED PROSJEKTET OG HVORFOR DU BLIR SPURT

Vi spør deg om å delta i et forskningsprosjekt der vi studerer hvordan eksperimentell smerte påvirker beslutningstaking i et databasert kortspill. Utfallet fra denne studien kan hjelpe oss å få en bedre forståelse om samspillet mellom smerte og sentralnervesystemet, som videre kan føre til en bedre forståelse av kognitive utfordringer og problemer hos mennesker med kroniske smertelidelser.

Til tross for at dette prosjektet handler om smerte og kognisjon, vil vi trenge en kontrollgruppe som gjennomfører kortspillet uten at de får smertestimulering. Du blir tilfeldig puttet inn i enten en smertegruppe (høyere varme) eller en varmegruppe (lavere varme) når du ankommer laboratoriet. Vi vil estimere de individuelle smerteopplevelsesnivåene for begge gruppene.

Vi ser etter friske voksne mennesker innenfor aldersgruppen 18-50 år

- Du bør ha godt eller korrigert syn, kan ikke ha noen nåværende/tidligere klinisk diagnose av psykiske/psykiatriske, nevrologiske eller kronisk smertesykdommer (f.eks. depresjon, bipolar lidelse, epilepsi, migrene, alvorlig hodeskade, hjernekirurgi), og kan ikke innta medisiner som påvirker sentralnervesystemet (f.eks. antidepressiva, anti-epileptika). I tillegg er det viktig at du ikke har tatt noen analgetiske midler (smertestillende, f.eks. Paracet) samme dagen som forsøket skal gjennomføres
- Du har ingen tidligere erfaring med kortspillet (e.g. har ikke deltatt i lignende studie)
- Det er viktig at du får nok søvn på nettene før dagen, må ikke være under påvirkning av psykoaktive stoffer (f.eks. alkohol, narkotika) og at du ikke lider av bakrus
- Du har lov til å innta koffein (f.eks. kaffe, energidrikk) og nikotin (f.eks. røyk, snus) i henhold til dine vanlige rutiner
- Vi ber deg om å ikke ta på parfyme eller kosmetikk (f.eks. krem, anti-bac) på innsiden av begge for-armene

HVA INNEBÆRER PROSJEKTET FOR DEG?

I prosjektet vil vi innhente og registrere opplysninger om deg. Vi kommer ikke til å samle inn informasjon som gjør det mulig å identifisere deg som person. Vi kommer bare til å spørre deg om alder, kjønn og din dominante hånd samt estimere ditt smerteoppfattelsesnivå. Vi skal samle inn data om responsene dine under kortspillet for å lære mer om dine beslutningstakingsstrategier. Til slutt, vil vi samle inn spørreskjemaer som omhandler ditt humør og personlighet, ved bruk av validerte og velbrukte standardiserte spørreskjemaer.

- Du vil bli bedt om å komme til vårt laboratorium på Instituttet for Psykologi ved UiT - Norges Arktiske Universitet og signere informert samtykke ved ankomst. Datainnsamlingen vil vare i omtrent **90** minutter. En av våre forskere kommer til å instruere deg på veien
- Først vil du bli bedt om å fullføre ulike spørreskjema som omhandler ditt humør
- Videre, vi kommer til å estimere ditt individuelle smerteoppfattelsesnivå for å kunne finne ut av hvilken stimuleringsintensitet du skal ha under selve kortspillet. Vi vil estimere det på innsiden av din dominante for-arm
- Når dette er kartlagt, vil du bli bedt om å spille et datastyrt kortspill. Den vil bestå av 5 blokker, hvorav hver av dem varer i 7.5 minutter. Etter at du har spilt ferdig hvert av de fem rundene av kortspillet vil du bli spurt om å svare på to skalaer som måler (1) hvor suksessfullt du følte at din prestasjon var og (2) hvor mye kontroll du følte at du hadde under kortspillet. I blokk 2 og 4, vil vi introdusere varmebasert smerte (moderat intensitet) til huden på innsiden av for-armen på den ikke-dominante armen din som vil vare i 7.5 minutter (med en pause fra smerte i blokk 3). Etter begge stimuleringsperiodene vil du bli spurt om å rangere (3) toppnivået av smerte du følte og (4) gjennomsnittsnivået av smerte du følte i blokk 2 og 4 . Prosedyren er helt trygg, og blir brukt verden rundt av forskere for å bedømme hvordan smerte påvirker kognisjon i friske deltakere og i pasienter med varierende lidelser
- Etter kortspillet vil du bli informert til å besvare fire spørreskjemaer som omhandler ditt humør og andre aspekter av din personlighet ("PANAS" og "BHS" som spør om humør, "BIS / BAS" som handler om generelle holdninger og "NFC" Need for Cognition, som handler om hvor villig man er til å bruke mentale krefter)
- På slutten av eksperimentet vil du få et gavekort til Jekta Storsenter med en verdi av enten **300** eller **400 NOK**, avhengig av din prestasjon på kortspillet

MULIGE FORDELER OG ULEMPER

- Fordelen ved å delta på dette prosjektet er at du lærer mer om hvordan man måler påvirkningen av smerte på ens kognisjon i et laboratorium samt bidra til forskningen og samfunnet. I tillegg, vil du få et gavekort på **300 NOK** på Jekta Storsenter for din deltakelse. Ved tilstrekkelig prestasjon på kortspillet vil du kunne motta en bonus på **100 NOK**
- Vi induserer varmebasert smerte på huden av innsiden av for-armen din for 7.5 minutter, 2 ganger. Her forsøker vi å nå målet om å indusere et moderat nivå av smerte, som vil være ukomfortabelt. Vi tar i bruk et PATHWAY-system av bedriften Medoc (www.medoc-web.com/pathway), som er en veldokumentert og mye brukt enhet for å indusere varmebasert smerte på både friske voksne mennesker og andre pasientgrupper. Stimuleringsintensiteten vil bli avklart før vi starter selve kortspillet, slik vi finner en varme som er tilpasset akkurat deg og som er tolerabel over lengre tid. Vi kommer bare til å ta i bruk enheten innenfor dens trygge sikkerhetshetsrammer
- Du kan alltids stoppe smertestimuleringen i løpet av kortspillet hvis du føler at smerten er for intens og du ønsker at den skal stoppe. Det vil alltid være en knapp ved siden av deg som terminerer stimuleringen helt
- Som en etter-effekt av å ha blitt påført varmebasert smerte på huden vil du kunne oppleve rødhet og sensitivitet i disse områdene. Denne effekten er ikke farlig og er helt normal og vil vanligvis vare i og forsvinne etter ca. 12 timer. Skulle dette vedvare i over 24 timer, ber vi deg om å ta kontakt med forskningsansvarlig Gábor Csifcsák som har medisinsk kompetanse og er alltid tilgjengelig for kontakt (s. 4)

FRIVILLIG DELTAKELSE OG MULIGHET FOR Å TREKKE DITT SAMTYKKE

- Det er frivillig å delta i prosjektet
- Dersom du ønsker å delta, undertegner du samtykkeerklæringen (s. 5) når du får tildelt ditt deltakelsestidspunkt og kommer til vårt laboratorium
- Du har rett til å avbryte datainnsamlingen til enhver tid og å trekke din samtykke om studiedeltakelse uten å oppgi en grunn for din beslutning. I dette tilfellet blir data som er samlet hittil ødelagt og ikke brukt på noen som helst måte. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg
- Du kan kreve innsyn i opplysningene som er lagret om deg, og opplysningene vil da utleveres innen 30 dager
- Du kan kreve at dine helseopplysninger i prosjektet slettes
- Adgangen til å kreve destruksjon, sletting eller utlevering gjelder ikke dersom materialet eller opplysningene er anonymisert eller publisert. Denne adgangen kan også begrenses dersom opplysningene er inngått i utførte analyser, eller dersom materialet er bearbeidet
- Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte prosjektleder (s. 4)

HVA SKJER MED OPPLYSNINGENE OM DEG?

- Opplysningene som registreres om deg skal kun brukes slik som beskrevet under formålet med prosjektet
- Eventuelle utvidelser i bruk og oppbevaringstid kan kun skje etter godkjenning fra REK og andre relevante myndigheter
- Du har rett til innsyn i hvilke opplysninger som er registrert om deg og rett til å få korrigert eventuelle feil i de opplysningene som er registrert
- Du har også rett til å få innsyn i sikkerhetstiltakene ved behandling av opplysningene. Du kan klage på behandlingen av dine opplysninger til Datatilsynet og institusjonen sitt personvernombud
- Alle data blir samlet inn anonymt, og er kun merket med en spesiell kode
- Du har rett på tilgang til dine data (smertepersepsjonsnivå, ytelse på beslutningstakingsoppgaven, resultatene av spørreundersøkelsene) ved forespørsel, men du må selv huske din deltakelsesdato og din deltakerkode
- Siden vi ikke samler inn personlig identifiserbar informasjon om deg som deltaker av studien, vil dataen vi samler inn under eksperimentet forbli 100% anonymt. Denne innsamlede dataen vil bli brukt for den hensikt å publisere resultater av vår studie i et vitenskapelig tidsskrift. Den innsamlede dataen vil bli presentert på gruppenivå og ikke på individnivå, noe som betyr at ingen individuelle data vil bli presentert i vitenskapelige publikasjoner eller universitetsoppgaver, bare resultater som ble oppnådd for hele gruppen av deltakere
- Publisering av resultater er en nødvendig del av forskningsprosessen. All publisering skal gjøres slik at enkeltdeltakere ikke skal kunne gjenkjennes, men vi plikter å informere deg om at vi ikke kan utelukke at det kan skje
- Vi vil også dele dataene med andre forskere for å legge til rette for vitenskapelig utvikling innenfor dette forskningsdomenet

DELING AV OPPLYSNINGER OG OVERFØRING TIL UTLANDET

Ved å delta i prosjektet, samtykker du også til at kodede opplysninger om dine smerterapporteringer, intensitet av smertestimuleringer, prestasjon på kortspillet og spørreskjema om humør og personlighet kan overføres til utlandet som ledd i forskningssamarbeid og publisering i tråd med formålet angitt innledningsvis. Disse anonyme dataene vil bli gjort tilgjengelig for andre forskere over hele verden for vitenskapelige hensikter. På bakgrunn av dette, vil vi bruke non-profitt Open Science Framework (osf.io), som er en plattform kun med hensikt å dele vitenskapelig forskningsdata og promotere transparens og et åpent forskningsnettverk.

- Ved å signere informert samtykke (s. 5), sier du deg enig i at data fra deg som deltaker kan bli delt med andre forskere. Andre forskere kan også ta i bruk denne dataen til å finne ut mer om eksperimentell smerte og dets påvirkning på beslutningstaking, og/eller hvorfor effekten av eksperimentell smerte på beslutningstaking blir påvirket av humør og personlighet. Vi planlegger å dele datainnsamlingen for en ubegrenset tidsperiode
- Vi ønsker også om å informere om at det er lovverket i det landet opplysningene oppbevares i som er gjeldene

FORSIKRING

Produktansvarsloven gjelder for dette prosjektet.

ØKONOMI

Du vil motta et gavekort på Jekta Storsenter i Tromsø av en verdi på 300 eller 400 NOK avhengig av din prestasjon. Dette forskningsprosjektet er finansiert av IPS, ved UiT og har ingen eksterne sponsorer. Forskerne og forskningsansvarlige på dette prosjektet har ingen interessekonflikter.

GODKJENNINGER

Regional komité for medisinsk og helsefaglig forskningsetikk har gjort en forskningsetisk vurdering og godkjent prosjektet **284408.**

Instituttet for Psykologi og prosjektleder Gábor Csifcsák er ansvarlig for personvernet i prosjektet.

Vi behandler opplysningene på linje med Personvernombud.

KONTAKTOPPLYSNINGER

Dersom du har spørsmål til prosjektet eller ønsker å trekke deg fra deltakelse, kan du kontakte:

Forskningsansvarlig, Gábor Csifcsák | **gabor.csifcsak@uit.no**

+47 776 46 776

Dersom du opplever etter-effekter etter gjennomført studie som ikke går over etter 24 timer, kontakt:

Forskningsansvarlig, Gábor Csifcsák | **gabor.csifcsak@uit.no**

+47 776 46 776

Dersom du har spørsmål om personvernet i prosjektet, kan du kontakte personvernombudet ved institusjonen:

Personvernombud ved UiT, Joakim Bakkevold | **personvernombud@uit.no**

https://uit.no/om/art?p_document_id=594059&dim=179007

Samtykke

Jeg erkjenner herved at jeg forstår all informasjon beskrevet ovenfor, og jeg gir mitt samtykke til å delta i studien.

Jeg forstår at det er min rett til å avbryte studien når som helst, uten å måtte oppgi en grunn for min beslutning. I dette tilfellet vil alle data som allerede har blitt samlet bli ødelagt, og ingen av dataene vil bli brukt på hvilken som helst måte.

Alle data vil bli samlet inn og holdes anonymt og vil være tilgjengelig for de ansvarlige for denne studien. Resultatene av denne studien vil kun bli presentert i vitenskapelige publikasjoner eller på et universitet avhandling på gruppenivå.

Jeg forstår at dataene som blir samlet inn i denne studien samles inn for et forskningsformål og er ikke samlet inn for å etablere noen kliniske diagnoser. Derfor vil jeg ikke be om noen diagnostisk mening.

JEG SAMTYKKER TIL Å DELTA I PROSJEKTET OG TIL AT MINE PERSONOPPLYSNINGER BRUKES SLIK DET ER BESKREVET

Sted og dato	Deltakers signatur
	Deltakers navn med trykte bokstaver

Appendix B a)

PANAS-Past

PANAS-Nå

Her kommer et spørreskjema med noen ord som beskriver ulike følelser og stemninger. Les hvert ord og skriv det tallet som best viser hvor mye du føler på denne måten *akkurat nå*.

1 = Veldig lite eller ikke i det hele tatt
2 = Litt
3 = Moderat
4 = En god del
5 = Ekstremt

	Følelse/stemning	Svar
1	Interessert/nysgjerrig	
2	I nød	
3	Opprømt	
4	Opprørt	
5	Sterk	
6	Skyldig	
7	Skremt	
8	Fiendtlig	
9	Entusiastisk	
10	Stolt	
11	Irritabel	
12	Våken/energisk	
13	Skamfull	
14	Inspirert	
15	Nervøs	
16	Besluttsom	
17	Oppmerksom	
18	"Skvetten"	
19	Aktiv	
20	Redd	

Appendix B b)

PANAS-Present for both pre-task and post-task

PANAS-Past

Her kommer et spørreskjema med noen ord som beskriver ulike følelser og stemninger. Les hvert ord og skriv det tallet som best viser hvor mye du har følt på denne måten *den siste måneden*.

1 = Veldig lite eller ikke i det hele tatt
2 = Litt
3 = Moderat
4 = En god del
5 = Ekstremt

	Følelse/stemning	Svar
1	Interessert/nysgjerrig	
2	I nød	
3	Opprømt	
4	Opprørt	
5	Sterk	
6	Skyldig	
7	Skremt	
8	Fiendtlig	
9	Entusiastisk	
10	Stolt	
11	Irritabel	
12	Våken/energisk	
13	Skamfull	
14	Inspirert	
15	Nervøs	
16	Besluttsom	
17	Oppmerksom	
18	"Skvetten"	
19	Aktiv	
20	Redd	

Appendix B c)

BIS/BAS

BIS/BAS

Hvert punkt av dette spørreskjemaet er en påstand en kan enten være enig eller uenig i. Hvert punkt indikerer hvor mye du er enig eller uenig med hva punktet sier. Vennligst svar på alle punktene og ikke la noen av boksene stå tomme. Velg kun et svar til hver påstand. Vennligst svar så presist og ærlig som mulig. Svar på hvert punkt som om det er det eneste punktet. Det betyr at du burde ikke tenke på å være konsis i svarene dine. Velg et svar fra de oppgitte fire alternativene og kryss av en boks.

		veldig sant for meg	delvis sant for meg	delvis usant for meg	veldig usant for meg
1.	Familien er det viktigste i et menneskes liv	☐	☐	☐	☐
2.	Selv når noe ille er i ferd med å skje med meg blir jeg sjelden redd eller nervøs	☐	☐	☐	☐
3.	Jeg gjør alt jeg kan for å få det jeg vil ha	☐	☐	☐	☐
4.	Når jeg gjør noe bra, liker jeg veldig godt å fortsette med det	☐	☐	☐	☐
5.	Jeg er alltid innstilt på å prøve noe nytt hvis jeg tror det kommer til å bli gøy	☐	☐	☐	☐
6.	Det er viktig for meg hvordan jeg kler meg	☐	☐	☐	☐
7.	Når jeg får noe jeg vil ha, føler jeg meg oppstemt og full av energi	☐	☐	☐	☐
8.	Kritikk eller kjeft sårer meg ganske mye	☐	☐	☐	☐
9.	Når det er noe jeg vil ha, gjør jeg vanligvis mitt ytterste for å få det.	☐	☐	☐	☐
10.	Ofte gjør jeg ting uten noen annen grunn enn at det kan være gøy	☐	☐	☐	☐
11.	Jeg synes det er vanskelig å finne tid til å gjøre slikt som å gå til frisøren	☐	☐	☐	☐
12.	Hvis jeg ser en mulighet til å få tak i noe jeg vil ha, handler jeg umiddelbart	☐	☐	☐	☐
13.	Jeg føler meg temmelig urolig og engstelig når jeg tror eller vet at noen er sinte på meg	☐	☐	☐	☐
14.	Når jeg ser en mulighet som jeg liker, blir jeg straks opprømt	☐	☐	☐	☐
15.	Ofte handler jeg ut fra hvordan jeg føler meg i øyeblikket	☐	☐	☐	☐
16.	Hvis jeg tror at noe ubehagelig kommer til å skje, blir jeg vanligvis temmelig opprørt.	☐	☐	☐	☐
17.	Jeg lurer ofte på hvorfor mennesker oppfører seg som de gjør	☐	☐	☐	☐
18.	Når fine ting hender meg, går det sterkt inn på meg	☐	☐	☐	☐
19.	Jeg føler meg urolig når jeg tror jeg har gjort det dårlig på noe som er viktig	☐	☐	☐	☐
20.	Jeg føler et sug etter spenning og nye opplevelser	☐	☐	☐	☐
21.	Når jeg legger meg etter noe jeg vil ha, lar jeg ingenting hindre meg	☐	☐	☐	☐
22.	Jeg har veldig mange færre ting jeg er redd for, sammenlignet med mine venner	☐	☐	☐	☐
23.	Å vinne en konkurranse ville gjøre meg opprømt	☐	☐	☐	☐
24.	Jeg bekymrer meg for å gjøre feil	☐	☐	☐	☐

Appendix B d)

BHS

BHS

Dette spørreskjemaet inneholder en liste med tjue påstander. Vennligst les hver påstand nøye en etter en.

Hvis påstanden beskriver din holdning den siste uken, inkludert i dag, så krysser du av i ruten for "Riktig".
Hvis påstanden ikke stemmer overens med din holdning den siste uken, inkludert i dag, så krysser du av for "Galt".

Husk å les hver setning nøye.

		Riktig 1	*Galt* 2
1.	Jeg ser på fremtiden med håp og entusiasme	☐	☐
2.	Jeg kan like godt gi opp fordi jeg ikke kan gjøre ting bedre for meg selv	☐	☐
3.	Når ting går dårlig, hjelper det meg å vite at de ikke kan forbli slik bestandig	☐	☐
4.	Jeg kan ikke forestille meg hvordan livet mitt vil være om 10 år	☐	☐
5.	Jeg har nok tid til å gjennomføre de ting jeg ønsker	☐	☐
6.	I fremtiden forventer jeg å lykkes med det som opptar meg mest	☐	☐
7.	Fremtiden min ser mørk ut	☐	☐
8.	Jeg forventer å få mer ut av de gode ting i livet enn en gjennomsnittsperson	☐	☐
9.	Jeg sitter bare ikke i hell og det er ingen grunn til å tro at jeg gjør det i fremtiden	☐	☐
10.	Mine tidligere erfaringer har forberedt meg godt for fremtiden min	☐	☐
11.	Alt jeg kan se foran meg er ubehageligheter heller enn behageligheter	☐	☐
12.	Jeg forventer ikke å oppnå det jeg virkelig ønsker	☐	☐
13.	Når jeg ser på fremtiden, forventer jeg at jeg vil være lykkeligere enn jeg er nå	☐	☐
14.	Ting vil bare ikke ordne seg på den måten jeg ønsker det	☐	☐
15.	Jeg har stor tro på fremtiden	☐	☐
16.	Jeg oppnår aldri det jeg ønsker så det er dumt å ønske seg noe i det hele tatt	☐	☐
17.	Det er svært lite trolig at jeg blir tilfreds i fremtiden	☐	☐
18.	Fremtiden ser uklar og usikker ut for meg	☐	☐
19.	Jeg kan se frem til flere gode stunder enn vanskelige	☐	☐
20.	Der er ingen nytte i å virkelig prøve å oppnå noe jeg ønsker, fordi jeg sannsynligvis ikke vil klare det	☐	☐

Appendix B e)

NFC

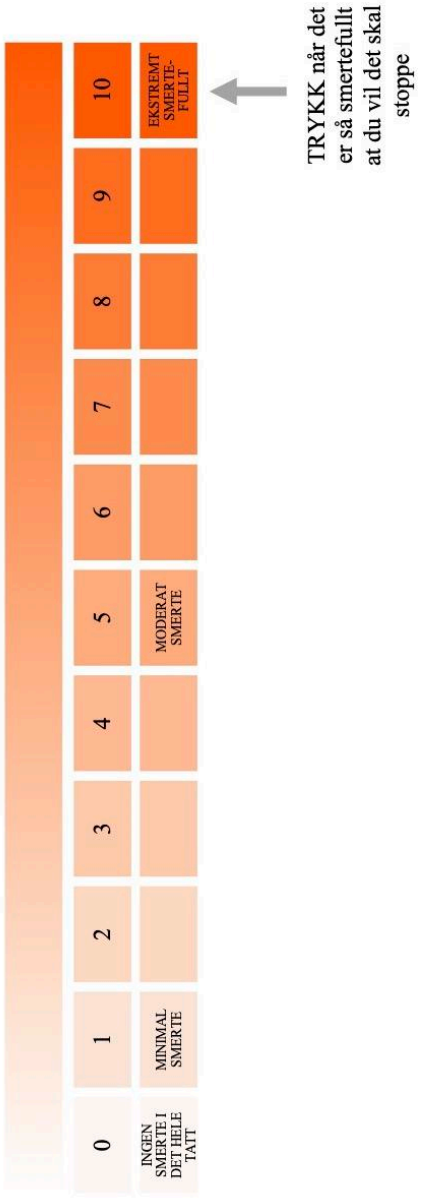
Under finner du en del spørsmål om hvordan du vanligvis arbeider, og forholde deg til ulike oppgaver, og hvordan du takler utfallet av ulike hendelser. Gi din ærlige og oppriktige mening. Det er ingen rette eller gale svar. Det er viktig at du angir hva du vanligvis gjør - hva som er typisk for deg.

Sett kryss i den boksen som beskriver best i hvilken grad du er enig i påstandene nedenfor.

	Passer svært dårlig				**Passer svært bra**
	1	**2**	**3**	**4**	**5**
1. Jeg foretrekker komplekse fremfor enkle oppgaver/problemer.	☐	☐	☐	☐	☐
2. Jeg liker å ha ansvar for situasjoner som krever mye tenkning.	☐	☐	☐	☐	☐
3. Tankevirksomhet er ikke det jeg synes er mest gøy.	☐	☐	☐	☐	☐
4. Jeg gjør heller noe som krever lite tankearbeid, fremfor noe som utfordrer min tankekapasitet (evne).	☐	☐	☐	☐	☐
5. Jeg prøver å forutse og unngå situasjoner hvor det er en sjanse for at jeg må tenke grundig/i dybden om noe.	☐	☐	☐	☐	☐
6. Jeg finner det tilfredsstillende å fundere og "gruble" lenge og grundig på problemer/ oppgaver jeg kan løse.	☐	☐	☐	☐	☐
7. Jeg tenker bare så "hardt" og grundig som det kreves i situasjonen.	☐	☐	☐	☐	☐
8. Jeg foretrekker å tenke på mindre, daglige prosjekter fremfor oppgaver/ prosjekter som tar tid.	☐	☐	☐	☐	☐
9. Jeg liker oppgaver som krever lite tankearbeid når en først har lært det.	☐	☐	☐	☐	☐
10. Ideen om å bruke min intellektuelle kapasitet til å komme meg til topps virker fristende for meg.	☐	☐	☐	☐	☐

Appendix C

VAS Pain

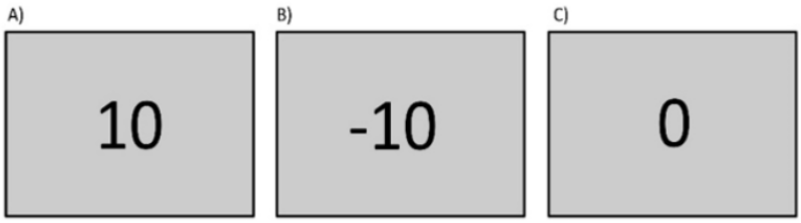


Appendix D

Quiz

QUIZ **CODE: _____**

1. **Sett en ring rundt bokstaven under hvert utsagn som korresponderer med den korrekte tallboksen**



- «Ikke vinne» eller «ikke tape»

  A B C

- Å tape

  A B C

- Å vinne

  A B C

2. **Bestem om utsagnet er riktig eller feil**

• Hvis jeg svarer riktig vil jeg alltid vinne	☐RIKTIG	☐FEIL
• For et «vinn-kort», er et utfall på «0» et dårlig utfall	☐RIKTIG	☐FEIL
• Det er alltid verdt å plukke opp et kort	☐RIKTIG	☐FEIL
• For et «tap-kort», er et utfall på «0» et dårlig utfall	☐RIKTIG	☐FEIL
• Hvis jeg svarer feil vil jeg alltid tape	☐RIKTIG	☐FEIL
• Noen ganger kan jeg få «-10» etter et «vinn-kort»	☐RIKTIG	☐FEIL
• Hvis jeg svarer feil, har jeg gode sjanser for å oppnå best mulig utfall	☐RIKTIG	☐FEIL
• Noen ganger kan jeg få «0» etter et «tap-kort»	☐RIKTIG	☐FEIL
• Noen ganger kan jeg få «10» etter et «tap-kort»	☐RIKTIG	☐FEIL
• Hvis jeg svarer riktig, har jeg gode sjanser for å oppnå best mulig utfall	☐RIKTIG	☐FEIL
• Noen ganger kan jeg få «0» etter et «vinn-kort»	☐RIKTIG	☐FEIL
• Det er aldri verdt å plukke opp et kort	☐RIKTIG	☐FEIL