

# Clinical pain, abstraction, and self-control: being in pain makes it harder to see the forest for the trees and is associated with lower self-control

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**Objectives:** Although abstract thinking is a fundamental dimension of human cognition, it has received scant attention in research on pain and cognition. We hypothesized that physical pain impairs abstraction, because when people experience pain at high intensity levels, attention becomes concretely focused on the self in the here and now, where little else matters than finding relief for the pain they are currently experiencing. We also examined the relationship between pain and self-control, predicting that pain would debilitate self-control.

**Patients and methods:** Abstraction and self-reported self-control were assessed in 109 patients with musculoskeletal pain. The influence of specific pain qualities, such as pain intensity, pain interference with daily activities, pain duration, and pain persistence, was examined. Furthermore, we assessed other factors (e.g., anxiety, depression, and fatigue) that could be assumed to play a role in the pain experience and in cognitive performance.

**Results:** Higher pain intensity and persistence were associated with less abstract thinking. Furthermore, self-control decreased with greater pain intensity, persistence, and self-reported pain interference with daily activities. Self-reported depressive symptoms mediated the overall relationship between pain and self-control.

**Conclusion:** Abstraction is compromised in patients reporting higher pain intensity and persistence. Different dimensions of pain also predict lower self-control although depression seems to account for the relationship between overall pain and self-control. The current study is the first to report an association between clinical musculoskeletal pain and abstraction. The results suggest that pain patients may suffer from a broader range of cognitive disadvantages than previously believed.

**Keywords:** abstraction, self-control, clinical pain, musculoskeletal pain, cognition

## Introduction

In the clinic, chronic pain patients often report problems with cognitive function,<sup>1</sup> and a body of research has investigated the impact of pain on cognitive functions in clinical pain states.<sup>2-4</sup> Despite its central role in human cognition,<sup>5-7</sup> abstraction has received sparse attention in pain research. This is surprising given that it also plays a critical role in behavior with important societal implications such as learning, creativity, self-regulation, and moral behavior.<sup>5,7</sup>

## What exactly is abstraction?

Abstraction is typically conceptualized as a process of information reduction, making effective storage and categorization of central knowledge possible.<sup>5</sup> It is characterized

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by holistic, “gist-based” thinking that allows us to see the broader picture – the proverbial forest for the trees.<sup>7</sup> Abstraction thus highlights the superordinate meaning of action rather than its detailed mechanics.<sup>8</sup> For example, it is typically characterized by a focus on why actions are performed, as opposed to how they are performed. To illustrate, the act of writing an article could be construed concretely as “pressing keys on the computer”, or more abstractly as “communicating results to the scientific community”.

Whether people think abstractly or concretely has multiple determinants, ranging from individual differences in cognitive style to contextual variables, such as power.<sup>5</sup>

One of the most extensively studied influences of abstract thinking is psychological distance. Research has shown that when the psychological distance from an object or event becomes larger, people use more abstract information processing.<sup>7</sup> This happens, for example, when we think about other people as opposed to ourselves (social distance), when we decide for the future rather than the present (temporal distance), and when we contemplate the hypothetical situation instead of the real situation (hypotheticality). Conversely, a focus on the self, here and now, reflects more concrete thinking.

Whether abstract thinking is beneficial depends on the context and the task at hand.<sup>7</sup> For example, abstraction can help us see the bigger picture and think outside the box when solving problems.<sup>9</sup> At the same time, abstract, oversimplified representations of future situations are believed to cause various forms of planning errors including the common tendency for people to underestimate the time required to complete a given project.<sup>10</sup>

To the best of our knowledge, only two studies have examined the impact of pain on abstraction. In a laboratory experiment where pain was manipulated using the cold pressor method, it was found that pain-induced participants did not differ from pain-free control participants with respect to abstraction, suggesting that abstraction at least seems to be relatively immune to short-lived, acute pain, although the experiment did not have sufficient power to rule out small effects of pain on abstraction.<sup>11</sup> In another article, no evidence for an association between pain interference with daily activities and abstraction in a sample of chronic pain patients was found.<sup>12</sup> The authors of this study tested the specific hypothesis that experiencing pain on a daily basis would interfere with abstract action identification that helps people attach overall meaning to actions. The authors found no support for this hypothesis. However, these latter results were inconclusive and should be interpreted with caution given the small sample size ( $N = 46$ ), and the study was

underpowered (0.56) to detect a moderate effect ( $r = 0.30$ ). Therefore, it is too premature to rule out a relationship between clinical pain and abstraction. In addition, probing for an association between pain and abstraction in clinical samples rather than among healthy participants with induced short-lived experimental pain<sup>11</sup> may be more promising, considering that the more long-lasting, persistent pain often experienced in clinical pain populations should have exerted a greater toll on the brain anatomy responsible for abstraction compared to short-lived, experimentally induced pain.<sup>13,14</sup>

The theoretical basis for hypothesizing a link between abstraction and pain draws on multiple fields. First, research on the neuroscientific correlates of pain suggests that physical pain interferes with activity in neural structures (e.g., prefrontal cortex) that also play an important role in abstraction.<sup>13,14</sup> Second, theories on the operations on visceral factors propose that when people experience visceral factors (drive states, moods, emotions, and physical pain) at high intensity levels, the concrete goal of immediately mitigating the visceral factor becomes paramount.<sup>15</sup> Thus, visceral factors cause attentional narrowing, and turn people’s focus inwardly on oneself in the here and now, which is also consistent with pain patients who often report temporal myopia and that nothing else matters than the pain they are currently experiencing.<sup>12,16</sup> According to construal level theory (CLT), such narrow focus on the self (vs. others), the present (vs. future), and one’s immediate (vs. remote) physical surroundings reflects concrete cognitive processing.<sup>7</sup> The main hypothesis of the current study is that physical pain should be associated with more concrete (less abstract) thinking.

A secondary aim of the current study was to examine whether physical pain also debilitates self-control, which previous studies have found to be facilitated by abstraction.<sup>17</sup> Self-control has been defined in different ways but typically refers to the capacity to inhibit undesirable automatic responses and aligning behavior with superordinate long-term goals, ideals, values, morals, and social expectations.<sup>18</sup> People exert self-control when they, for example, resist the urge to eat unhealthy but tasty food, to say inappropriate things to their colleagues, and to cheat on their taxes. Two major types of cognitive processes that are theorized as facilitating self-control are abstraction<sup>17</sup> and effortful controlled cognitive processing that enables inhibition of automatic responses.<sup>18,19</sup> Regarding the role of abstraction in self-control conflicts, abstraction is believed to direct attention to superordinate (long-term) goals, whereas concrete thinking is believed to draw attention to more subordinate (short-term) goals. To illustrate, for dieters, abstraction should help make long-term

health goals increasingly salient, and the short-term goal of satisfying cookie cravings less salient. Because pain was hypothesized to decrease abstraction, which in turn facilitates self-control, our second hypothesis states that pain would also hamper self-control. There are also theories viewing self-control as requiring effortful controlled cognitive processes.<sup>18,19</sup> Since pain has been suggested to limit cognitive resources,<sup>1</sup> it may also affect self-control negatively via its debilitating effect on controlled processing. For this reason, the mediating role of both abstraction and resource-depleting factors was assessed in relation to self-control.

## Patients and methods

### Power analysis

An a priori power analysis using G\* Power (Franz Faul, Universität Kiel, Germany) was performed. We aimed to achieve a power level of 90% to be able to detect a moderate effect size ( $r = 0.30$ ) with alpha level set to 0.05 (two-tailed). Following these criteria in the context of the current correlational study, a minimum sample of 109 participants would be required.

### Study population

A cross-sectional, correlational study was conducted, where patients seeking a physiotherapist for the treatment of musculoskeletal pain at a primary care center in Sweden were recruited. A sample of patients with clinical musculoskeletal pain was chosen, since these diagnoses are common in society and responsible for high societal costs.<sup>20,21</sup> It could be argued that other forms of clinical pain most likely share some of the psychological components involved in musculoskeletal pain, such as pain-related fear, anxiety, and depression.<sup>22</sup>

Exclusion criteria were exercising with breathlessness prior to the test session that same day, depression as a primary diagnosis, known disease causing cognitive or motor

impairment, brain damage, blindness, known drug or alcohol abuse, being under 18 years of age, and not being fluent in Swedish. Due to lack of time, some patients declined to participate ( $n=7$ ). In total, 109 patients participated. The gender composition of the sample was 32 males and 77 females. With respect to education, 19 participants had a university degree, 60 had completed upper secondary school, and 30 had completed compulsory school. The age ranged from 19 to 83 years ( $M = 53$  years). Every patient record was searched for exclusion criteria after the first meeting, and the patient was asked about exclusion criteria at the first meeting. Two different physiotherapists diagnosed the patients. All participants signed an approved informed consent form, and the study has been approved by the regional ethics review board in Linköping (2015/432-31). The study was performed during the spring of 2017.

All patients were diagnosed according to ICD-10. If the patient fitted into more than one diagnostic category, they were placed in the category which resembled the problem for which they were seeking physiotherapist treatment (pain localization is given in Table 1).

## Instruments

### Currently experienced pain intensity

To assess the currently experienced pain intensity, the widely used Visual Analogue Scale (VAS) was used.<sup>23</sup> The scale consists of a line which ranges from zero (marked as “no pain”) to 10 (marked as “worst pain imaginable”).<sup>24</sup> The participants were asked to “put a cross on the line according to how their pain was perceived at the current moment”. Thus, this pain rating reflected the pain experienced at the test session ( $M = 3.60$ ,  $SD = 2.67$ ). Since pain measurements are subjective, the VAS is a subjective scale, and therefore other factors external to the immediate pain sensation, such as the current mood, past experiences, and expectations, will influence every pain

**Table 1** Number of participants in every pain location, diagnosed according to ICD-10

Participants	Shoulder pain	Low back pain	Cervical pain	Knee pain	Fibromyalgia syndrome	Fracture in lower extremity	Lateral epicondylitis	Foot pain	Hip pain	Hand pain	Others
N	27	21	14	19	4	3	3	6	2	3	7

**Notes:** Among the patients with shoulder pain, 25 were diagnosed as having impingement syndrome (M754), and two were diagnosed as having frozen shoulder (M750). In the group with low back pain, three patients experienced radiating pain from a herniated disk (M51), five patients experienced radiating pain to one leg without a herniated disk (M544), and the rest experienced low back pain without radiation (M545). In the group with cervical pain (M542), two patients experienced radiating pain to one upper extremity. Among the patients with knee pain, 15 had knee osteoarthritis (M17), two had meniscus ruptures (S832), one had unspecific knee pain (M239), and one was diagnosed with chondromalacia patellae (M224). In the group with foot pain, three had a distortion to the ankle (S934), one had metatarsalgia (M774), and two had Achilles tendinitis (M766). In the group with hip pain, one had hip osteoarthritis (M16) and one had a trochanter bursitis (M706). In the group with hand pain, one had arthrosis of the thumb (M181), one had Mb de Quervain's syndrome (M654), and one had carpal tunnel syndrome (M560). In the group marked as others, all had unspecified enthesopathies (M779).

rating.<sup>25</sup> Therefore, patients appear to differ in their ability to use the VAS reliably.<sup>26</sup> Nevertheless, the VAS is typically regarded to be a valid scale to measure and compare experimental heat pain and chronic pain.<sup>27</sup> Moreover, the VAS is a traditional method of pain measurement; it is simple, effective, and widely used in both research and the clinic.<sup>23</sup>

### Experienced pain intensity and interference with daily activities during the past 24 hours

The Brief Pain Inventory-short form (BPI-SF) was used to measure the experienced intensity of pain and the influence of pain on everyday activities during the past 24 hours. It has been reported that the BPI-SF has good validity and reliability in different languages, and it has been widely used in different countries.<sup>28</sup> The ratings were made on a scale ranging from 0 (no pain) to 10 (worst pain imaginable) for BPI-SF-intensity ( $M = 4.68$ ,  $SD = 1.93$ ) and 0 (no interference) and 10 (very large interference) for the BP-SF-interference ( $M = 4.49$ ,  $SD = 2.48$ ).

### Pain duration

When completing the anamnestic questionnaire, the participants indicated when they first experienced the pain that they were currently suffering from. This duration response was calculated to reflect the number of days since the first pain episode ( $M = 4.4$  years,  $SD = 9$  years).

### Pain persistence

To assess pain persistence, the participants indicated (%) how much of the time they were in pain ( $M = 59$ ,  $SD = 32$ ).

### Abstraction

The extensively used Behavioral Identification Form (BIF<sup>8</sup>) was used to measure abstraction. Participants were presented with two descriptions of an action and had to choose which description best describes the action. The two descriptions varied in abstractness with the abstract description referring to the overall purpose of the action (i.e., why the action was performed) and the concrete description referring to the detailed mechanism of action (i.e., how it was performed). For example, the action “taking a test” was followed by “showing one’s knowledge” (abstract action identification) and “answering questions” (concrete action identification). Concrete identifications were coded as 0, and abstract identifications were coded as 1. We calculated an average abstraction score for each participant ( $M = 0.65$ ,  $SD = 0.18$ ).

The BIF contains 25 items, and the test–retest reliability has been reported to be 0.91. No test–retest reliability of the Swedish version has been found, but the internal consistency

has been fair ( $\alpha = 0.85$  and  $0.82$ ) when the Swedish version has been used in earlier studies.<sup>11,29</sup>

### Self-control

To examine self-control in the current study, the Brief Self-Control Scale was used. The Brief Self-Control Scale is a short form of the Self-Control Scale.<sup>30</sup> The Brief Self-Control Scale has been shown to correlate 0.93 and 0.92 with the long version and contains the same parts as the original scale.<sup>30</sup> Fair internal consistency ( $\alpha = 0.83$  and  $0.85$ ) has been reported in two independent studies.<sup>30</sup> The Brief Self-Control Scale has been shown to correlate positively with grade point average, interpersonal skills, secure attachment, adjustment, and adaptive emotional responses and negatively with binge eating and alcohol abuse.<sup>30</sup> Examples of items from the scale to be graded are “I’m good at resisting temptation” and “I do things that feel good in the moment but regret later on”.

### Pain-related variables

We also measured a number of other variables that could be assumed to play a role in both the pain experience and cognitive performance: physical exercise, fatigue, anxiety, depression, pain-relieving medication, age, education.<sup>31–43</sup> These were assessed by our anamnestic background information questionnaire or by separate questionnaires.

### Resource-depleting variables

#### Anxiety and depression

To measure any presence of anxiety and depression in our sample, the Hospital Anxiety and Depression (HAD<sup>44</sup>) Scale was used. Seven items measured anxiety, and seven items measured depression. Highest possible total score for the anxiety ( $M = 4.99$ ,  $SD = 4.27$ ) and depression ( $M = 2.93$ ,  $SD = 3.01$ ) subscales was 21, and the lowest possible score was 0. The validity of HAD scale has been reported to be good in measuring the presence of anxiety and depression in primary care patients, and the internal consistency has been good as well with  $\alpha = 0.6$ .<sup>45</sup>

#### Fatigue

Participants reported how much of the time they felt tired (%;  $M = 49$ ,  $SD = 30$ ).

#### Patient information

##### Education

Participants provided information about education (completed compulsory school, completed upper secondary school, and completed university degree).

## Medication

Participants provided information about whether they were taking pain-relieving medication (18% were on pain relief medication, medications used in the sample were paracetamol, nonsteroidal anti-inflammatory drugs, selective serotonin reuptake inhibitors, monoamine oxidase inhibitors, pregabalin and gabapentin).

## Physical exercise

Participants self-reported how much physical exercise they typically engage in every week (0 minutes, <30 minutes, 30–60 minutes, 60–90 minutes, 90–120 minutes, >120 minutes).

## Procedure

Patients seeking a physiotherapist at a Swedish primary care center were asked to participate in the study if they fitted the inclusion and exclusion criteria. Two different physiotherapists distributed the test materials. The participants were comfortably seated in a quiet room and completed all measures at their own pace. The participants first provided background information and answered specific questions concerning the persistence and duration of their pain. Next, they completed the forms in the following order: BPI-SF, HAD scale, the VAS, the abstraction, and self-control scales. The participants were also presented with a creativity task consisting of the triangle problem.<sup>46</sup> The reason for this was that we planned to assess also creativity, as creativity also draws on abstraction.<sup>7</sup> Although our pretest of the task on an independent student sample showed satisfactory variation, in the current sample, the dependent variable (solved vs. not solved) was heavily restricted in the range with only 19 participants (17.4%) managing to solve the problem. Thus, we had too low statistical power to allow for a meaningful statistical analysis. The whole test session took approximately 15 minutes to complete. A thorough debriefing concluded the session.

## Results

When inspecting the data, it was clear that some variables were not normally distributed, and thus nonparametric correlational analyses were reported. Table 2 summarizes Spearman correlations among the studied variables,<sup>2</sup> and Table 3 summarizes reliability analyses for the questionnaires used in the study.

As summarized in Table 2, our hypothesis that pain impairs abstraction received some support in the data with both BPI-SF pain intensity and pain persistence showing

statistically significant ( $p < 0.05$ ) negative correlations with scores on the BIF. That is, the higher pain intensity experienced during the past 24 hours and the more percent of time that participants estimated that they were in pain were associated with actions being identified in less abstract terms. Current pain intensity experienced during the testing (VAS) and BPI-SF pain interference correlated with BIF scores in the same direction, although these correlations did not reach statistical significance. Pain duration and BIF scores did not show any signs of a correlation. Viewed together, there is some support for the hypothesis that pain impairs abstraction.

Concerning the hypothesis that pain impairs self-control, all pain variables (except for pain duration) showed significant ( $p < 0.05$ ) negative correlations with self-control. In other words, more pain was associated with lower self-control. Specifically, self-control diminished with increasing pain intensity (experienced at the time of the testing and during the past 24 hours), stronger pain persistence, and more self-reported pain interference with everyday activities.

Because anxiety, depression, and fatigue correlated significantly with self-control and the same pain indicators (i.e., VAS, BPI-SF-intensity, BPI-SF-interference, and pain persistence) that were also significantly associated with self-control, we could examine their role as potential mediators in a subsequent analysis. As anticipated, besides correlating negatively with some of the pain indicators, as reported earlier, abstraction also correlated significantly and positively with self-control. A mediation analysis was considered helpful with the potential to shed additional light on some of the mechanisms underlying the relationship between pain and self-control. For the sake of parsimony, we do not report separate mediation analyses for each of four pain indicators that were significantly related to anxiety, depression, fatigue, and self-control, rather they were merged into a total pain index. As summarized in Table 2, the pain variables were substantially related, allowing for the creation of a total pain index. The new pain index correlated significantly with the suspected mediators, depression, anxiety, fatigue, and abstraction ( $p < 0.04$ ) as well as the dependent variable self-control).

To establish mediation, we followed the procedures outlined by<sup>47,48</sup> using PROCESS macro path analysis modeling tool for SPSS (IBM Corporation, Armonk, NY, USA).<sup>48</sup> When estimating the indirect effect of pain through the four suspected mediators (anxiety, depression, fatigue, and abstraction) simultaneously, bias-corrected bootstrap confidence intervals (CIs; OLS) around the indirect effect of pain were calculated with the number of bootstrap samples



Table 2 Spearman correlations

Variables	Statistic	Abstraction	Self-control	VAS	BPI-SF intensity	BPI-SF daily activities	Pain persistence	Pain duration	HAD anxiety	HAD depression	Fatigue	Education	Age
Abstraction	Spearman's $\rho$	–	0.224*	–0.141	–0.201*	–0.102	–0.202*	–0.053	–0.042	–0.128	–0.119	0.044	–0.024
	p-value	–	0.020	0.146	0.037	0.294	0.039	0.588	0.664	0.190	0.219	0.654	0.808
Self-control	Spearman's $\rho$	–	–	–0.216*	–0.220*	–0.193*	–0.261**	0.004	–0.363***	–0.434***	–0.285**	0.129	0.164
	p-value	–	–	0.025	0.022	0.046	0.007	0.971	<0.001	<0.001	0.003	0.184	0.092
VAS	Spearman's $\rho$	–	–	–	0.707***	0.588***	0.657***	0.121	0.260**	0.260**	0.267**	–0.057	–0.140
	p-value	–	–	–	<0.001	<0.001	<0.001	0.212	0.007	0.007	0.005	0.559	0.148
BPI-SF intensity	Spearman's $\rho$	–	–	–	–	0.654***	0.725***	–0.002	0.207*	0.257**	0.367***	–0.181	–0.060
	p-value	–	–	–	–	<0.001	<0.001	0.986	0.031	0.007	<0.001	0.060	0.536
BPI-SF interference	Spearman's $\rho$	–	–	–	–	–	0.528***	0.036	0.416***	0.420***	0.541***	–0.021	–0.181
	p-value	–	–	–	–	–	<0.001	0.713	<0.001	<0.001	<0.001	0.832	0.062
Pain persistence	Spearman's $\rho$	–	–	–	–	–	–	0.011	0.321***	0.337***	0.286**	–0.185	–0.090
	p-value	–	–	–	–	–	–	0.912	<0.001	<0.001	0.003	0.058	0.364
Pain duration	Spearman's $\rho$	–	–	–	–	–	–	–	0.223*	0.249**	0.070	–0.057	0.059
	p-value	–	–	–	–	–	–	–	0.021	0.009	0.473	0.559	0.543
HAD anxiety	Spearman's $\rho$	–	–	–	–	–	–	–	–	0.676***	0.407***	0.027	–0.317***
	p-value	–	–	–	–	–	–	–	–	<0.001	<0.001	0.784	<0.001
HAD depression	Spearman's $\rho$	–	–	–	–	–	–	–	–	–	0.455***	–0.093	–0.121
	p-value	–	–	–	–	–	–	–	–	–	<0.001	0.338	0.215
Fatigue	Spearman's $\rho$	–	–	–	–	–	–	–	–	–	–	0.019	–0.225*
	p-value	–	–	–	–	–	–	–	–	–	–	0.848	0.020
Education	Spearman's $\rho$	–	–	–	–	–	–	–	–	–	–	–	–0.404***
	p-value	–	–	–	–	–	–	–	–	–	–	–	<0.001
Age	Spearman's $\rho$	–	–	–	–	–	–	–	–	–	–	–	–
	p-value	–	–	–	–	–	–	–	–	–	–	–	–

**Notes:** Correlation matrix for correlations between the outcome variables (BIF and Self-Control Scale) and the independent variables (VAS, BPI-SF pain intensity, BPI-SF pain interference with daily activities, HAD anxiety measure, HAD depression measure, educational level, pain duration, pain persistence, fatigue, and age. Significant correlations are marked as \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

**Abbreviations:** BIF, Behavioral Identification Form; BPI-SF, Brief Pain Inventory-short form; HAD, Hospital Anxiety and Depression; VAS, Visual Analogue Scale.

set to 5000. As recommended,<sup>48</sup> unstandardized effects ( $b$ ) are reported (Figure 1). The analysis showed that depression ( $b = -0.036$ ) was a significant mediator of the relationship between pain and self-control as the 95% CI ( $-0.101, -0.005$ ) did not contain zero. In contrast, anxiety ( $b = -0.027$ ) and fatigue ( $b = -0.025$ ) were not significant mediators as their 95% CIs did include zero, ( $-0.082, 0.007$ ) and ( $-0.079, 0.002$ ), respectively (performing separate mediation analyses for each pain indicator yielded similar results). Thus, pain indirectly influenced self-control through its effect on depression. The direct effect of pain was not significant ( $b = -0.055, p = 0.303$ ), meaning that there is no evidence that pain influenced self-control independently of its effect on depression. In sum, these results suggest that patients reporting more overall pain feel more depressed, which in turn debilitates self-control although the correlational nature of the results does not allow us to draw causal conclusions.

## Discussion

The primary aim of this study was to investigate the hypothesis that clinical musculoskeletal pain impairs abstraction. The theoretical basis for this hypothesis builds on neurobiological,

motivational, and cognitive perspectives. First, pain interferes with activity in the prefrontal cortex,<sup>13</sup> which plays an important role in abstraction and cognitive control.<sup>49</sup> Second, from a motivational perspective, when people experience visceral factors (e.g., drive states, moods, emotions, and physical pain) at high intensity levels, nothing else seems to matter than the pain they are experiencing.<sup>15,16</sup> Specifically, visceral factors are assumed to cause attentional narrowing, thereby resulting in a focus inwardly toward the self in the here and now.<sup>15</sup> A narrow perspective that omits others, the future, and one's remote surroundings reflects a concrete level of mental construal.<sup>7</sup> Because it has been shown that abstraction plays a role in self-control,<sup>17</sup> we also hypothesized that pain would impair self-control. We chose to study self-control because it plays an important role in numerous intrapersonal (e.g., health) and interpersonal domains (e.g., moral behavior).<sup>30</sup>

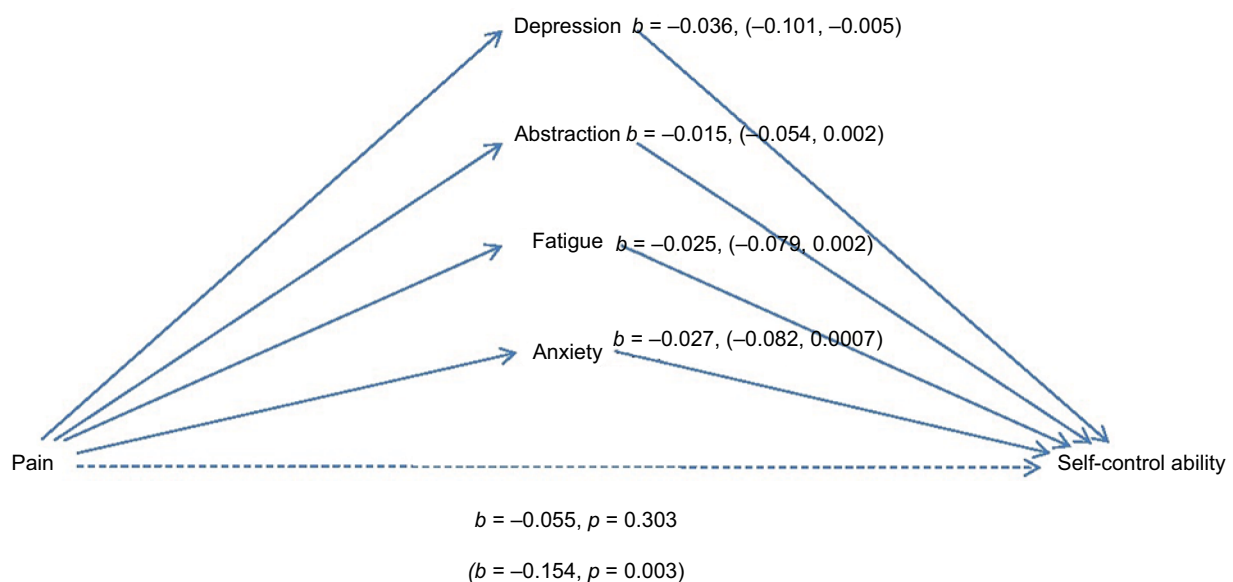
Our data yielded some support for the hypothesis that pain impairs abstraction as some, but not all, of our measured pain indicators correlated significantly with abstraction. Specifically, greater pain intensity and persistence were associated with lower levels of abstraction. The pain intensity experienced at the test session showed a similar pattern as the

**Table 3** Reliability coefficients for the action identification, self-control measure, brief pain inventory as well as HAD scale

Internal consistency	BIF	Self-Control Scale	BPI-SF intensity	BPI-SF daily activities	HAD anxiety	HAD depression
Cronbach's $\alpha$	0.789	0.765	0.916	0.920	0.877	0.599

**Notes:** Cronbach's alpha for the BIF, the BPI-SF, and the HAD form.

**Abbreviations:** BIF, Behavioral Identification Form; BPI-SF, Brief Pain Inventory-short form; HAD, Hospital Anxiety and Depression.



**Figure 1** Schematic description of the mediation analysis.

**Notes:** Unstandardized beta coefficients ( $b$ ) are reported. Bottom, the numbers refer to the (direct) effect of pain on self-control, controlling for the mediators. The numbers in parenthesis refer to the (total) effect of pain on self-control without controlling for the mediators.

intensity experienced during the past 24 hours, although it did not reach statistical significance. This was also the case for self-reported pain interference with everyday activities. Pain duration was also not associated with abstraction, suggesting that the intensity and persistence of pain matter more. In sum, abstraction seems to be impaired in patients who experience more intense pain and/or frequent pain, although the size of observed correlations suggest that the effect is likely to be small. Nevertheless, this may have consequences for pain patients in their everyday lives as many tasks (e.g., problem solving and creativity) typically require abstract thinking.<sup>5</sup>

The finding that pain persistence rather than pain duration matters for abstraction suggests that even in those patients who experience long-term, regular, recurrent pain, the brain has some pain-free time to rest and recover from the pain signals. In persistent pain, no such recovery takes place, and it could therefore be assumed that this indeed would be detrimental to different brain functions. Other research provides some support for this interpretation. For example, it has been suggested that long-term, persistent pain is responsible for functional and structural alterations in the brain.<sup>50–53</sup> Furthermore, research has found a more detrimental effect in cognitive function, as well as in deep tissue pressure pain thresholds, for long-term persistent pain compared to long-term, regularly, recurrent pain.<sup>54,55</sup>

The negative association between pain and abstraction is inconsistent with an earlier study,<sup>12</sup> which found no association between pain and abstract action identification when assessing abstraction as a mediator between pain and sense of meaning in life in a sample of chronic pain patients. As in the current study, they measured pain intensity, pain interference in daily activities, and pain duration. It is not clear from their study to what extent the pain patients suffered from persistent pain, which turned out to be an important predictor in the current study. In addition, the sample included patients with multiple sclerosis, and several different cognitive impairments frequently coexist with this disease,<sup>56</sup> which makes it difficult to conclude if the painful signals to the brain alone would affect abstraction, since other cognitive impairment could also influence the cortical processing. More importantly, the small sample size in this study could explain why an association between pain and abstraction was not found as it was underpowered to detect even a moderate effect. If the association between pain and abstraction is small as suggested by the current study, it is not surprising that they did not find an effect.

The results are also interesting with respect to an earlier experimental study,<sup>11</sup> which showed that (otherwise pain-free)

participants with induced short-lived acute pain did not think less abstractly compared to the control group. However, acute pain induced by the cold pressor method is not the same as clinical pain, and it has been reported that brain activity is different in clinical pain states compared to short-lasting, experimental pain,<sup>50</sup> and therefore the influence of clinical pain on mental functions could be different. In addition, it seems reasonable to assume that compared to short-lived acute pain, persistent pain that lasts for longer periods of time should have greater potential to produce chronic changes in cognitive styles.

In relation to the hypothesis that pain impairs self-control, pain intensity, interference, and persistence were negatively associated with lower self-control. The only pain indicator that did not correlate with self-control was pain duration. Interestingly, the extent to which the patients reported feeling depressed mediated the relationship between overall pain and self-control. Although pain appears to decrease abstraction, abstraction did not significantly mediate the relationship between pain and self-control.

It is well established that depression is closely intertwined with clinical pain states.<sup>22</sup> Our finding that patients who reported feeling more depressed, also reported lower self-control, could be interpreted in terms of cognitive resource depletion, because depression tends to deplete cognitive resources that involve slow, effortful, and controlled thinking,<sup>57</sup> which play an important role in resisting temptations that undermine self-control.<sup>30</sup> Although two conceptually independent cognitive processes in the form of controlled cognitive processing<sup>30</sup> and abstraction<sup>17</sup> have been theorized to underlie successful self-control, when it comes to pain, specifically, the current data revealing a mediating role of depression, but not abstraction, suggest that the reduction in controlled processing, rather than abstraction, provides a better explanation for the debilitating effect of pain on self-control. Of course, because our mediation analysis is based on correlational data, we cannot draw any causal conclusions.

## Limitations

A limitation in our study is the heterogeneity among the musculoskeletal diagnoses represented in our primary care sample. It could be possible that different musculoskeletal pain locations could be associated with abstraction to different extents. A further limitation is that the current correlational design does not allow us to draw any causal conclusions regarding pain, abstraction, and self-control. The observed relationships could be caused by other variables that were



not measured or controlled for in the current study. However, we made serious attempts to account for factors previously associated with pain and cognitive function (education, physical exercise, medication, anxiety, depression, and fatigue). Since these variables did not correlate with abstraction, they are unlikely to explain the relationship between pain and abstraction. In addition, it is possible that the directionality is reversed with abstraction serving a pain-regulating function. Although this possibility awaits empirical confirmation, research has shown that an abstract, self-distanced perspective reduces negative affect.<sup>58</sup>

## Conclusion

The current results provide some support for an association between clinical pain and abstraction. Specifically, as pain intensity and persistence increase, the ability to think abstractly is somewhat reduced. Moreover, pain seems to have an indirect relationship with self-control, and this relationship seems to be exerted through feelings of depression following the clinical pain experience. To the best of our knowledge, this is the first research showing that pain is associated with more concrete cognitive processing. Obviously, more studies are needed to clarify the directionality of the association between different pain qualities and abstraction. Furthermore, it is important that future studies are sufficiently powered to detect even small effects as even a small effect of clinical pain on abstraction could be societally important, since millions of people are afflicted by daily pain,<sup>59</sup> and abstraction plays an important role in many human domains.<sup>5,7</sup> In addition, if the ability to exert self-control is reduced in pain patients with coexisting, secondary depression, this could influence the ability to follow treatment plans and guidelines provided in the clinic. Exactly, how pain influences abstraction and important downstream consequences is an important question to be addressed in the future research.

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## Author contributions

All authors contributed toward data analysis, drafting and revising the paper and agree to be accountable for all aspects of the work.

## Disclosure

The authors report no conflicts of interest in this work.

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