Faculteit Psychologie en Pedagogische Wetenschappen
Onderzoeksgroep Gezondheidspsychologie
KU Leuven

Faculteit Psychologie en Pedagogische Wetenschappen
Vakgroep Experimenteel-Klinische en Gezondheidspsychologie
UGent

Pain in context:

The effect of goal competition on pain-related fear and avoidance

Nathalie Claes

Proefschrift aangeboden tot het verkrijgen van de academische graad van Doctor in de Psychologie in het kader van een gezamenlijk doctoraat aan de KU Leuven en de Universiteit Gent

Promotoren: Prof. Dr. Johan W.S. Vlaeyen
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Nathalie Claes. Pijn in context: Het effect van doelcompetitie op pijn-gerelateerde vrees en vermijding. Proefschrift aangeboden tot het verkrijgen van de academische graad van Doctor in de Psychologie in het kader van een gezamenlijk doctoraat aan de KU Leuven en de Universiteit Gent, 2016.
Promotoren: prof Dr. Geert Crombez (UGent), prof. Dr. Johan Vlaeyen (KU Leuven)

Het Vreesvermijdingsmodel gaat ervan uit dat pijn-gerelateerde vrees en vermijdingsgedrag een cruciale rol spelen in het behoud en de verergering van chronische pijnproblemen. Zowel experimentele als klinische studies hebben herhaaldelijk ondersteuning voor dit model geleverd. Er zijn echter een aantal onopgeloste kwesties die verder wetenschappelijk onderzoek vereisen. Eén van de uitdagingen is dat pijn(gedrag) niet in een motivationeel vacuüm plaatsvindt, maar dat het doel om pijn te vermijden interageert met andere, vaak concurrerende, doelen. Er wordt bijgevolg gesteld dat het vreesvermijdingsmodel baat zouden hebben van een uitbreiding met een motivationeel perspectief. Het doel van dit proefschrift is het experimenteel onderzoeken van de gevolgen van doelcompetitie op pijn-gerelateerde vrees en vermijdingsgedrag. Daarnaast wilden we ook de aanwezigheid en de ervaring van doelconflicten in een klinische populatie van patiënten met chronische pijn bestuderen.

Hiertoe werd een serie van experimenten uitgevoerd die voortbouwen op een bestaand differentieel vreesconditioneringsparadigma, namelijk het Voluntary Joystick Movement Paradigm. In een typisch experiment voltooien gezonde vrijwilligers bewegingen in verschillende richtingen. Sommige van deze bewegingen gaan gepaard met pijnlijke electrocutane stimuli. Eveneens konden bij sommige bewegingen loterijtickets gewonnen of verloren worden. Experiment I.1 (N=55) toonde aan dat het presenteren van een gelijktijdige beloning vermijdingsgedrag verminderde, maar dat pijn-gerelateerde vrees onveranderd bleef. Experiment I.2 (N=57) bevestigde deze bevindingen, en toonde bovendien aan dat deze effecten werden gemoduleerd door het geprioriteerde doel. Experiment II.1 (N=48) toonde aan dat competitie tussen twee vermijdingsdoelen meer angst installeerde en besluitvorming meer vertraagde dan andere competitie-types. De resultaten van Experiment III.1 (N=46) lieten zien dat cues die pijn voorspellen meer pijn-gerelateerde angst en vermijdingsgedrag induceerden, en dat deze cues doelcompetitie installeerden wanneer ze gepresenteerd werden in combinatie met een beweging die was geassocieerd met beloning. Experiment III.2 (N=42) toonde aan dat hoewel pijnvermijding prominent aanwezig was, een pijn cue resulteerde in minder pijn-vermijdingsgedrag in vergelijking met een neutrale of beloning cue. Om de tweede doelstelling van deze dissertatie te onderzoeken, namen patiënten met fibromyalgie (N=40) en gezonde controles (N=37) deel aan een semigestructureerd interview (studie IV.1). Meer dan de helft van de patiënten rapporteerden dat pijncontrole of -vermijdingsdoelen conflicteerden met andere doelen, zoals huishoudelijke activiteiten of sociale activiteiten.

Dit proefschrift levert nieuwe, experimentele evidentie voor de inclusie van een breed motivationeel perspectief in het Vreesvermijdingsmodel, en kan ook bijdragen tot de verbetering van de effectiviteit van bestaande cognitief-gedragsmatige behandelingen voor patiënten die lijden aan chronische pijn door doelcompetitie te includeren.

Nathalie Claes. Pain in context: The effect of goal competition on pain-related fear and avoidance. Thesis submitted to obtain the academic degree of doctor in Psychology in the context of a joint PhD at the KU Leuven and Ghent University, 2016.
Promotors: prof Dr. Geert Crombez (Ghent University), prof. Dr. Johan Vlaeyen (KU Leuven)

The Fear-Avoidance model proposes that pain-related fear and avoidance behavior play a key role in the maintenance and exacerbation of chronic pain problems. Both experimental and clinical studies have widely corroborated this model. However, there remain some unresolved issues that warrant further scientific scrutiny. One of the challenges is that pain (behavior) does not occur in a motivational vacuum, but that the goal to avoid pain interacts with other, often competing goals. It is argued that fear-avoidance models would benefit from the inclusion of a motivational perspective.

The main aim of this dissertation was to experimentally investigate the impact of goal competition on pain-related fear and avoidance behavior. Additionally, we studied the presence and experience of goal conflict in a clinical population.

For this purpose, a series of experiments building on a well-established differential fear conditioning paradigm, the Voluntary Joystick Movement Paradigm, was developed. In a typical experiment, healthy participants completed movements in different directions. Some of these movements were associated with painful electrocutaneous stimuli, whereas other movements were not. Likewise, movements could be associated with reward—in the form of lottery tickets—or the loss thereof. Experiment I.1 (N=55) demonstrated that presenting a concurrent reward attenuated avoidance behavior, but did not alter pain-related fear. Experiment I.2 (N=57) corroborated these findings, and additionally demonstrated that these effects were modulated by goal prioritization. Experiment II.1 (N=48) showed that avoidance-avoidance competition installed more fear and slowed down decision-making compared to other types of competition. Experiment III.1 (N=46) showed that cues predicting a painful outcome increased pain-related fear as well as avoidance behavior, and installed competition when combined with a movement that was associated with reward. Experiment III.2 (N=42) demonstrated that although pain avoidance was prominent, a pain cue was associated with less pain-avoidance behavior than a neutral or reward cue. To address the second aim of this dissertation, patients with fibromyalgia (N=40) and healthy, matched controls (N=37) participated in a semi-structured interview mapping the presence of goal conflicts (Study IV.1). More than half of the patients reported that pain control or avoidance goals conflict with other goals, such as household activities or social activities.

This dissertation provides novel experimental evidence for the inclusion of a broad motivational perspective in the Fear-Avoidance model, and may also help improve the effectiveness of existing cognitive-behavioral treatments for patients suffering from chronic pain by addressing goal competition.

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"A goal is a dream with a deadline" – Napoleon Hill

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Enjoy the ride.

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GENERAL INTRODUCTION

In this general introduction, we first provide a definition of chronic pain, and describe its characteristics, prevalence, and societal costs. Next, we briefly discuss the evolution of theoretical models that have been developed to better understand the inception, maintenance and exacerbation of chronic pain. The focus in this doctoral dissertation lies on a biopsychosocial view of pain, and more specifically the Fear-Avoidance model of chronic pain (Lethem, Slade, Troup, & Bentley, 1983; Vlaeyen & Linton, 2000; Vlaeyen & Linton, 2012). Recently, there have been calls to broaden the scope of the Fear-Avoidance model by including contextual and motivational information. Therefore, in the second part of this introduction,we focus on motivation and related constructs such as goals and goal competition. Next, we outline a motivational framework that might help progress our understanding of chronic pain, and briefly describe interventions (for chronic pain) that already incorporate motivational components in their treatment strategy. Finally, we discuss the overall project outline and the specific research aims of the current doctoral dissertation.

Pain

What is pain?

The most commonly used definition of pain is that of The International Association for the Study of Pain (IASP) stating that pain is "*an unpleasant sensory and emotional experience associated with actual or potential tissue or damage, or described in terms of such damage*" (Merskey & Bogduk, 1994, p. 210). This definition highlights that pain is a highly subjective experience, and that reporting pain is not necessarily tied to the presence of physical (tissue) damage. If one would ask different individuals diagnosed with a similar pain problem to describe their pain, it is highly likely that they each would give a different description. One individual might describe that pain feels as "a constant gnawing", whereas another person might report feeling "a hot, burning sensation at my lower back". To summarize "*pain is whatever the experiencing person says it is, existing whenever the experiencing person says it does*" (McCaffery & Pasero, 1999, p. 17).

Furthermore, pain essentially comprises of three components: (a) a sensory-discriminative component, for example reflecting (differences in) the intensity or the location of pain; (b) an affective-motivational component, that is, pain is always an unpleasant, and therefore an emotional experience; and (c) a cognitive-evaluative component, such as catastrophic ideas about pain (Melzack & Casey, 1968). Often, pain is acute, serving a protective purpose, and one can resume his/her daily activities after healing has taken place. Unfortunately, in some cases pain persists beyond healing time—defined as 3 months after pain onset—and becomes chronic (Merskey & Bogduk, 1994). Chronic pain no longer serves as a signal for danger, and may interfere with daily life to the extent that

patient no longer leave their homes. In the following paragraph, we take a closer look at the prevalence as well as the burden of chronic pain.

The cost and commonness of chronic pain

Chronic pain is a common health problem and can present itself throughout the lifespan to any individual, although it is more prevalent at older ages and in women (Tsang et al., 2008). Dependent on the methodology used and the studied population, prevalence rates of chronic pain varying from 8% to over 60% are reported (Phillips, 2009). A large scale survey that took place in 15 European countries (including Belgium) and Israel showed that chronic pain—defined as moderately to severely intense pain that lasts at least 6 months—affects approximately one in five Europeans (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006). Of the individuals reporting to suffer from chronic pain, 66% reported to have moderate pain—corresponding with a score ranging from 5 to 7 on a numerical rating scale (NRS)—and 34% reported severe pain, that is, a score ranging from 8 to 10 on an NRS (Breivik et al., 2006). Based on data from the World Health Organization (WHO, see Üstiin & Sartorius, 1995), collected from 15 different primary care centers all over the world, Gureje, Von Korff, Simon & Gater (1998) found that 22% of patients reported persistent pain. Note however that in both studies, there was a wide variation in prevalence rates across countries. In Belgium, the most recent health survey ("Gezondheidsenquête") from 2013 shows that about one in four (26%) respondents with an age of 15 years and older suffered from moderate to very intense pain during the four weeks preceding the survey. In this survey, higher levels of pain were reported by women, individuals with lower levels of education, and with increasing age (Drieskens, 2014).

Not only is chronic pain a common health problem, it can "*dominate, depress, and debilitate*" (Thienhaus & Cole, 2001, p. 29). Chronic pain can have possible detrimental consequences for the biological, social, economic and psychological well-being of the individual (Smith et al., 2001; Snelgrove & Liossi, 2013). When suffering from chronic pain, obtaining relief or at least control over pain becomes a prominent aspect of daily life, often, interfering with other activities (Thienhaus & Cole, 2001). Indeed, chronic pain seems to have a profound impact on the lives of the individual. First of all, chronic pain considerably impacts quality of life, and is—together with other musculoskeletal disorders—associated with some of the poorest quality of life indices (Breivik, Eisenberg, & O'Brien, 2013; Phillips, 2009; Sprangers et al., 2000). Importantly however, a study of Reitsma and Meijler (1997) demonstrated that individuals with chronic pain who did not seek medical help for their pain (nonconsumers) have a better quality of life than chronic pain patients who regularly consulted a doctor (consumers). The individual's well-being can be affected in different ways. For example, chronic pain may negatively affect the independent lifestyle, work, leisure and social activities, as well as the financial situation of individuals with chronic pain (Boonstra, Reneman, Stewart, Post, & Schiphorst Preuper, 2013). For example, in the national Health survey of Belgium, 36% of individuals

reporting pain stated that they felt hindered by their pain during normal work during the past 4 weeks (Drieskens, 2014). In the study of Breivik et al. (2006), 61% of respondents were less able or unable to work, 19% had lost their job, and 13% changed jobs because of their pain. Furthermore, the majority of participants reporting chronic pain stated that they were less able or unable to do household chores (54%), drive (47%), walk (47%), exercise (73%), or attend social activities (48%). Chronic pain also seems to be associated with mental disorders, especially depression and anxiety, further contributing to patients' suffering (Campbell, Clauw, & Keefe, 2003; Tsang et al., 2008).

Furthermore, chronic pain does not only impact on the life of the individual suffering, but also affects their family. Kowal, Wilson, McWilliams, Péloquin, and Duong (2012) showed that the majority of patients with chronic pain (70%) in their study felt like they placed a high burden on their environment. Moreover, this perceived burden correlated with similar feelings of burden reported by the patients' caregivers. Additionally, it has been shown that family members of patients suffering from chronic pain often report feeling powerless, distressed, socially isolated (West, Usher, Foster, & Stewart, 2012), and experience decreased marital and sexual satisfaction (Flor, Turk, & Scholz, 1987).

Pain also poses a significant societal and economic burden. It is even suggested that the costs due to pain are greater than most other health conditions such as heart disease, cancer, and diabetes (Breivik et al., 2013; Phillips, 2009). Given the personal burden of chronic pain, it should come as no surprise that chronic pain is one of the most common reasons to seek medical help. The numbers indicate that the majority of patients experiencing persistent pain consult medical workers (Andersson, 1999; Elliott, Smith, Penny, Smith, & Chambers, 1999; Loeser & Melzack, 1999). For example, in the pan-European study of Breivik et al. (2006), a striking 84% of respondents reported to have visited a medical doctor—most often a general practitioner—at least once in the six months preceding the survey. Furthermore, pain leads to greater absence from work because of pain (absenteeism), and musculoskeletal disorders—such as chronic pain—are also one of two health conditions clearly associated with disability benefits, contributing to the burden pain places on the society and economy (Dagenais, Caro, & Haldeman, 2008; Phillips, 2009).

To summarize, chronic pain poses a major health problem, and is not only associated with a considerable burden for the individual, but also for the direct environment and society. It should come as no surprise that as long as humans have experienced pain, they have tried to understand its development, perpetuation, and aggravation. In the next section, we discuss the evolution of our understanding of chronic pain.

The evolution in understanding pain

From a traditional biomedical perspective…

One of the earliest theories on the physiology of pain was *the specificity pain theory*. This traditional point of view is biomedical in nature and considered the body and mind to function separately and independently (Gamsa, 1994). Following the ideas of René Descartes ([1966] Descartes, 1972), this theory proposes that the human body functions like a machine and should be explained in mechanistic terms, whereas the mind is a non-physical substance related to feelings and thoughts. The only 'association' between both is that they are connected through the pineal gland. As a consequence, pain was considered the direct result of tissue pathology. More specifically, the specificity theory describes a unidirectional relationship between nociception and pain perception: specific 'pain receptors' at the level of the skin transmit signals via the nerves to a 'pain center' in the thalamus, at which point pain is perceived (Benini & DeLeo, 1999; Melzack & Wall, 1965; Moayedi & Davis, 2013). One of the implications of this theory is that simply removing the cause—cutting the specific nerves or taking away the painful stimulus—would 'cure' pain. However, a number of observations have shown that pain is not as unidirectional as proposed in this traditional view. A first observation was that cutting the nerves resulted in an exacerbation instead of an alleviation of pain in a great number of cases (Benini & DeLeo, 1999). Second, some patients report experiencing pain in the absence of an identifiable physical cause. This strict *biomedical* approach thus failed to provide a gratifying explanation for chronic pain. Instead, conceptualizing illness as a complex interaction of biological, psychological and social factors appeared to be a more satisfying approach (Gatchel, Peng, Peters, Fuchs, & Turk, 2007).

Towards a biopsychosocial model of chronic pain

In 1965, Ronald Melzack and Patrick Wall put forward their *Gate Control Theory* as a new, integrative theory of pain mechanisms (Melzack & Wall, 1965). Their model states that rather than passively receiving messages, the brain is actively involved in the process of pain perception. More specifically, they posit that there is a gating system located in the substantia gelatinosa in the dorsal horn of the spinal cord. This gating mechanism modulates the transmission of nerve impulses from primary *afferent* fibers to the spinal cord transmission (T) cells and is controlled by activity in ascending small (A-delta) fibers that tend to 'open the gate', as well as large (C) fibers that inhibit the gate (Moayedi & Davis, 2013). Furthermore, the gate can be modulated by the activity in descending fibers located in supraspinal regions: the gate opens when nociceptive information exceeds the elicited inhibition, activating pathways leading to the experience of pain (Moayedi & Davis, 2013, p. 9). Additionally, they proposed that this gating mechanism is also influenced by affective and cognitive information that is conveyed via descending nerve impulses from the brain through the *efferent* fibers (Melzack & Katz, 2004; Melzack & Wall, 1965). This theory was the first to integrate psychological

factors and physiological factors, revolutionizing pain research in general by paving the way for the development of a biopsychosocial approach to pain (Melzack & Katz, 2004; Moayedi & Davis, 2013).

Supposedly one of the first to call for a *biopsychosocial* model was George Engel (1977). As opposed to the traditional biomedical models, it was argued that pain arises as a consequence of biological, psychological, and social factors interacting with each other (Asmundson & Wright, 2004; Gatchel, 2005; Quintner, Cohen, Buchanan, Katz, & Williamson, 2008). To say it with a metaphor—paraphrasing Jason Gideon from the series *Criminal Minds*—our genetics load the gun, our psychology aims it, and our lifestyle or environment pull the trigger. This biopsychosocial approach provides a more complex and dynamic perspective on pain, and has resulted in a number of specific iterations over the years (*for an overview*, see Asmundson & Wright, 2004). In the next section, we focus on one of the most successful biopsychosocial models used to explain chronic pain development, that is, the Fear-Avoidance model (Lethem et al., 1983; Vlaeyen & Linton, 2000).

The Fear-Avoidance model of chronic pain

The Fear-Avoidance model of chronic (musculoskeletal) pain essentially describes two pathways in response to the experience of pain, initiated by an injury (see Figure 1, Lethem et al., 1983; Vlaeyen & Linton, 2000). In the first pathway (right pane on the figure), the individual appraises the experience as non-threatening, and confronts him/herself with the painful activities that initially resulted in the injury. This approach is considered adaptive, and ultimately leads to recovery, that is, being active despite pain. In the second pathway (left pane of the figure) however, individuals misinterpret the experience of pain as threatening or catastrophic, resulting in a vicious cycle of pain-related fear and avoidance behavior, as well as other defensive behaviors (e.g., escape and hypervigilance). This response is considered adaptive in the acute phase, but when sustained may paradoxically become maladaptive, ultimately leading to disability, disuse, and depression. The assumptions of the Fear-Avoidance model have been tested extensively, and are widely validated (Leeuw, Goossens, et al., 2007; Wertli, Rasmussen-Barr, Weiser, Bachmann, & Brunner, 2014; Zale, Lange, Fields, & Ditre, 2013).

In the next sections, we focus on two of the models' key components: pain-related fear and avoidance, before discussing some unresolved issues.

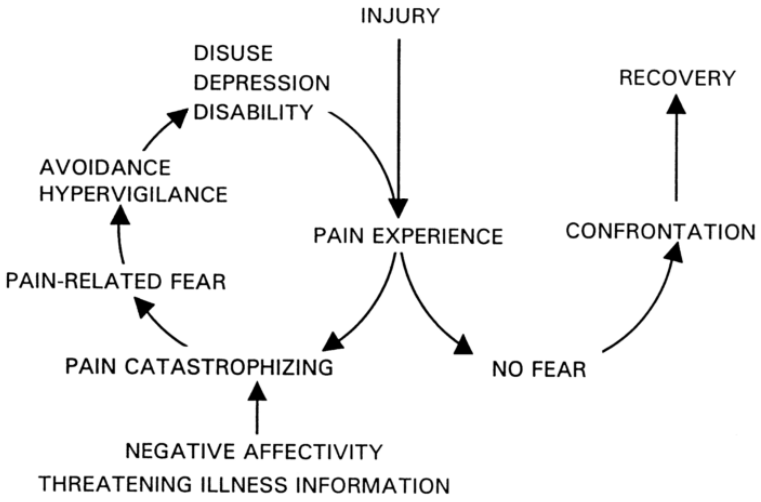

Figure 1. The Fear-Avoidance model of chronic pain (Vlaeyen & Linton, 2000, p. 329). Reprinted with permission.

Pain-related fear. As one of the core concepts of the Fear-Avoidance model, pain-related fear has received a lot of scientific attention, and its importance in the development and maintenance of chronic pain problems has been extensively demonstrated. Pain-related fear has shown to affect attentional processing of (information related to) pain, decreased physical activity, functional disability, and distress (Eccleston & Crombez, 1999; Leeuw, Goossens, et al., 2007; McCracken, Zayfert, & Gross, 1992; Van den Hout, Vlaeyen, Houben, Soeters, & Peters, 2001; Vlaeyen, Kole-Snijders, Boeren, & van Eek, 1995; Waddell, Newton, Henderson, Somerville, & Main, 1993; *for an overview*, *see* Asmundson, Norton, & Vlaeyen, 2004). But what is pain-related fear? As stated in the Encyclopedia of Pain, pain-related fear is a "*general term to describe different forms of fear with respect to pain*" (Helsen, Leeuw, & Vlaeyen, 2013, p. 1267). More specifically, pain-related fear is considered to be an anticipatory, often excessive, fearful response when pain is expected to arise (Kori, Miller, & Todd, 1990). The content of pain-related fear thus depends on what is anticipated. Fear may revolve around the occurrence of physical harm, the continuation or aggravation of pain, or may be directed at situations or activities. Sometimes, an individual may even fear that specific movements or activities will result in pain or (re)injury, which is called kinesiophobia (Kori et al., 1990; Volders, Leeuw, Vlaeyen, & Crombez, 2013).

In line with earlier theories on chronic pain, the Fear-Avoidance model proposes that associative learning is responsible for the development and maintenance of pain-related fear (Lethem et al., 1983; Philips, 1987; Vlaeyen & Linton, 2000), as is the case for the acquisition of fear in general (Lissek et al., 2005). Associative learning reflects a change in response to stimuli because of an association between two stimuli, or between behavior and stimuli (Vlaeyen, 2015). Two forms of associative learning can be discerned: Pavlovian or Classical conditioning and Instrumental or Operant

Conditioning. During a Pavlovian conditioning procedure (Domjan, 2005; Pavlov, 1927), an initially neutral conditioned stimulus (CS) such as a light is repeatedly followed by an aversive unconditioned stimulus (US; e.g., painful electrocutaneous stimulation) that automatically evokes a defensive response such as trying to escape stimulation (unconditioned response; UR). As a result of repeated pairings with the US, a CS-US representation forms, and consequently, the formerly neutral CS may evoke a fearful response (conditioned response; CR). For example, a pain patient may become fearful of lifting crates (CS) after having repeatedly experienced pain in the lower back (US) whilst putting groceries in the trunk of a car. In instrumental conditioning (Bouton, 2007; Skinner, 1948), an individual learns the association between an action (response; R) and its consequences (outcome; O), and thus allows for shaping behavior: behavior decreases when the outcome is aversive, and increases when the outcome is appetitive. Note that another stimulus (discriminative stimulus; SD) possibly signals that an action can be followed by a particular outcome (Domjan, 2005). For example, a child may learn that throwing a tantrum results in receiving candy when s/he is at his/her grandmother's house, but at home results in a time-out. As a consequence, the child will throw more tantrums at grandmother's, whereas it will stop doing so at home. A differential fear conditioning paradigm—which can be used in both Pavlovian and instrumental procedures—is widely accepted as an experimental approach to study fear acquisition in healthy subjects. In a differential fear conditioning paradigm, one originally neutral stimulus is associated with an aversive US, becoming a signal for danger or harm (CS+), whereas another neutral stimulus is never associated with the US (safety cue, CS-), allowing for a comparison between these two stimuli. To study fear of movement-related pain, Meulders, Vansteenwegen, and Vlaeyen (2011; 2012) developed the Voluntary Joystick Movement Paradigm (VJM). This paradigm uses proprioceptive cues—upper extremity movements performed with a joystick—instead of the often used exteroceptive cues (e.g., a light or a tone). Typically, participants are asked to perform movements in different directions using a joystick (CSs). A movement in a particular direction is then followed by a painful electrocutaneous stimulus (CS+), whereas a movement in another direction is not (CS-). After repeatedly performing 'painful' and 'safe' movements, participants responded more fearfully towards the painful movements than towards safe movements, as indicated by both verbal reports and eye blink startle response (Meulders et al., 2011). The VJM paradigm has proven to be an ecologically valid approach to study pain-related fear, and has been validated in several studies (e.g., Meulders, Vandebroek, Vervliet, & Vlaeyen, 2013; Meulders & Vlaeyen, 2012, 2013a, 2013b; Volders, Meulders, De Peuter, Vervliet, & Vlaeyen, 2012).

It is notable that different pathways may lead to the development of fear (Mineka & Sutton, 2006). The first pathway is direct experience (as described in the examples above). In the literature, it is shown that direct aversive experiences may contribute to the onset of several anxiety disorders (e.g., Lissek et al., 2005). For example, in panic disorders, the symptoms the individual was experiencing (e.g., nausea) or the particular room (CSs) the individual was in during the initial panic attack (US)

may come to elicit fear of panic, and may even result in another panic attack (CR; Bouton, Mineka, & Barlow, 2001). Second, fear can be acquired after observing others behaving fearfully towards an object or in a situation (Bandura, 1965). This process is referred to as modelling or vicarious/observational learning. Several researchers have experimentally demonstrated that pain-related fear can be acquired via vicarious learning (e.g., Helsen, Goubert, Peters, & Vlaeyen, 2011; Vandenbroucke et al., 2013). The third pathway is learning via verbal instructions (Muris, Bodden, Merckelbach, Ollendick, & King, 2003). In the case of chronic pain, especially the information health care professionals give (e.g., "please refrain from heavy lifting") may unintentionally cause patients to develop fear for those movements (Crombez & Kissi, 2015; Ostelo & Vlaeyen, 2008).

Furthermore, Peter Lang (1968, 1985) argued that fear in general comprises of three response systems: (1) a verbal response system, reflecting cognitions and beliefs individuals may have when experiencing fear and which may be expressed in language (e.g., saying "I feel afraid"); (2) a behavioral response system, for example moving away from the feared object/situation (e.g. avoidance, escape); and (3) a physiological response system, that is, bodily changes that the fearful individual may or may not be aware of (e.g., increased heartbeat, increased sweating,…). These response systems are considered to function relatively independent from each other, although they may affect each other as well (Lang, 1968). As such, to measure fear, one could assess one or more of these components. Each component can be assessed using different measures, which may not always correlate highly with each other. First, to assess cognitions and beliefs, self-reports can be used. In the context of an experiment, these self-reports can consist of one or several items answered immediately before or after a movement or retrospectively upon completion of an experimental block or even the experiment. In the Voluntary Joystick Movement paradigm for example, self-reported US expectancy and CS fear (Meulders et al., 2011) are measured separately. To assess trait/state pain-related fear, well-validated questionnaires, such as the Fear of Pain Questionnaire (FPQ; McNeil & Rainwater, 1998; Roelofs, Peters, Deutz, Spijker, & Vlaeyen, 2005) or the Pain Anxiety Symptoms Scale (PASS; McCracken, Zayfert, & Gross, 1992; Roelofs et al., 2004) can be employed. Second, it is common practice to collect reaction times such as response latencies—time of movement-onset—or response durations—time from movement-onset until movement-completion—to assess the behavioral component of fear (e.g., Meulders et al., 2011). Third, to tap into physiological component of fear, the fear-potentiated eye blink startle can be measured (Lang & McTeague, 2009).

Avoidance behavior. Avoidance is considered adaptive when aimed at legitimate threats, but becomes maladaptive when it is disproportionate with the threat (Barlow, 2002). According to the Fear-Avoidance model, (excessive) avoidance is considered a key feature in the maintenance and aggravation of chronic pain problems (Vlaeyen & Linton, 2000; 2012). A number of terms have been introduced to define avoidance behavior, but no consensus has been reached on the use of a single

term. The most overarching term encompassing avoidance behavior, is *safety-seeking behavior*, which is defined as behavior exerted in order to prevent or minimize an aversive event. Safety-seeking behavior refers to a broad spectrum of behavior, ranging from total avoidance—not engaging in a specific activity or situation—to more subtle instances of avoidance, such as performing the feared movement in a different way, for example squatting instead of bending over to pick something up (Salkovskis, 1996). Since it encompasses the different forms in which avoidant behavior can present itself, this broad definition fails to distinguish between forms of avoidance behavior based on the proximity of the threat: *avoidance behavior* is aimed at impending threats whereas *escape behavior* arises in the case of an ongoing threat. To differentiate between these two forms of behavior, the Encyclopedia of Pain (Gebhart & Schmidt, 2013, p. 240) proposes the following more specific definition of avoidance behavior: "*behavior aimed at avoiding or postponing undesirable situations or experiences. In chronic low back pain patients, avoidance behavior often consists of avoiding those activities that are believed to promote pain and/or (re)injury*", fitting well with the definition proposed by Pierce & Cheney (2008) that avoidance is behavior aimed at preventing or postponing the occurrence of an aversive event (*see also* Volders, Boddez, De Peuter, Meulders, & Vlaeyen, 2015). These definitions are in line with the definition proposed for pain-related fear, since they both focus on imminent or anticipated threats.

As is the case for the acquisition of fear, most theories on avoidance learning propose that both Pavlovian and Instrumental conditioning contribute to the acquisition of avoidance. One of the first—and also one of the most influential—models is the Two-Factor of Mowrer (1947; 1951). More specifically, this theory proposes that first, conditioned fear responding towards a neutral CS (e.g., a movement) arises after repeated pairings with an aversive US (e.g., painful electrocutaneous stimuli). Second, when later on a response (R; e.g., pressing a 'safety' button) is emitted in the presence of the CS, this action may result in the termination of conditioned fear. Note that Mowrer suggested that fear was a necessary condition for avoidance, as avoidance behavior is performed in order to escape the feared CS, rather than to avoid the US (Mowrer, 1960). This assumption was however rapidly disproved, as several studies showed that avoidance behavior still persisted after fear disappeared (e.g., Solomon, Kamin, & Wynne, 1953). Another critique is that Pavlovian conditioning is sufficient to acquire avoidance behavior as was demonstrated by Krypotos, Effting, Arnaudova, Kindt, and Beckers (2014; *see also* Krypotos, Effting, Kindt, & Beckers, 2015).

As opposed to the more functional account of Mowrer, other theories were developed including cognitive and informational factors to explain avoidance behavior. In 1973, Seligman and Johnston presented their Cognitive Theory of avoidance learning, which was later extended to the Expectancy model of Lovibond (Lovibond, 2006; Seligman & Johnston, 1973). In general, these cognitive accounts assume that individuals acquire knowledge on the occurrence of an aversive event

contingent on the (avoidant) response. More specifically, they posit that an individual learns to expect an aversive event if the avoidant response is not performed, and that the aversive event does not occur if the avoidant response is performed. As such, this account could explain the maintenance of avoidance behavior despite fear extinction. The most notable differences between the Cognitive Theory and the Expectancy model, are that according to the Expectancy model: (1) expectancies play a role in both Pavlovian and instrumental conditioning as opposed to only in instrumental learning; (2) awareness of the CS-US contingencies is crucial for Pavlovian conditioning; and (3) both Pavlovian and instrumental conditioning are based on propositional knowledge (Lovibond, 2006; Mitchell, De Houwer, & Lovibond, 2009). As a consequence of the reliance on propositional knowledge, the Expectancy model allows avoidance behavior to be acquired via direct experience, but also via other pathways, such as observational learning or instructional learning–as is the case for fear learning (Krypotos, Effting, et al., 2015; Rachman, 1977). Another theory that warrants mention is the account of De Houwer, Crombez, & Baeyens (2005; *see also* Declercq & De Houwer, 2008). This theory suggests that avoidance behavior can function as a negative occasion setter (*see* Holland, 1992). A negative occasion setter or feature—in this case, avoidance behavior—is a cue signaling that a specific CS or target is not going to be followed by the US. As such, these authors argued that avoidance behavior may have occasion setting properties as was corroborated in several of their studies (De Houwer et al., 2005; Declercq & De Houwer, 2008). Recently however, these researchers also found evidence opposing their theory (Declercq & De Houwer, 2011). Similarly, the studies of Meulders and colleagues (e.g., Meulders et al., 2011) indicate that proprioceptive stimuli such as movements can serve as CSs, evoking fear responses (Vlaeyen, 2015).

In sum, some models (e.g. Two-Factor Theory) have proposed that Pavlovian CSs evoking fear may serve as discriminative stimuli leading to behavioral responses such as avoidance behavior, consequently resulting in a decrease in fear; whereas other models (e.g., Negative Occasion Setter account) have proposed that behavioral responses such as avoidance can serve as conditioned stimuli.

In relation to the first proposition, it has been demonstrated that behavioral responses can be modulated by environmental cues (CSs) as well (Doya, 2008; Vlaeyen, 2015). The capacity of Pavlovian cues (CSs) to modulate the vigor of instrumental action is called Pavlovian-to-Instrumental Transfer (PIT; Cohen-Hatton, Haddon, George, & Honey, 2013; Holmes, Marchand, & Coutureau, 2010; Talmi, Seymour, Dayan, & Dolan, 2008). A typical PIT-procedure contains the following elements: (a) an instrumental acquisition phase in which subjects learn to associate two different response options (R1, R2) with a different appetitive outcome each (e.g., sucrose [O1] and food pellets[O2]); (b) a Pavlovian acquisition phase, in which subjects learn to associate one CS (e.g., a light) with the first outcome (O1), and a second CS (e.g., a tone) with the second outcome (O2). This Pavlovian acquisition phase can either precede or follow the instrumental acquisition phase; and (c) a PIT test, in which subjects are presented with both response options whilst one of the CSs is presented.

Two types of PIT effects can be discerned. First, Pavlovian cues may selectively increase the rate of responding for the response option associated with the same outcome; which is termed (outcome-) selective PIT. Second, Pavlovian cues may increase the rate of instrumental responding for both response options, even though they have never been associated with the same outcome, which is termed general PIT (Cohen-Hatton et al., 2013; Talmi et al., 2008). PIT has mainly been studied in appetitive settings, and mostly in non-human animals (Cohen-Hatton et al., 2013; Dickinson & Balleine, 1994; Holmes et al., 2010; Talmi et al., 2008). The effect of Pavlovian cues on avoidance behavior has only recently become a topic of scientific inquiry. Lewis, Niznikiewicz, Delamater, and Delgado (2013) for example demonstrated that instrumental (avoidance) responding selectively increased when a cue signaling a specific aversive outcome whose omission negatively reinforced the instrumental response was presented, and generally increased when cues predicting a dissimilar yet aversive outcome was presented.

Unresolved issues. The Fear-Avoidance model has been extensively validated, but some challenges remain (Crombez, Eccleston, Van Damme, Vlaeyen, & Karoly, 2012; Vlaeyen, Crombez, & Linton, 2009; Vlaeyen & Linton, 2012). It is widely accepted that pain is not simply a response to a stimulus, but a highly integrated event comprising of several components: (1) a sensory-discriminatory component, (2) a cognitive-evaluative component, and (3) an affective-motivational component. It is this last component that poses a particular challenge for both the clinician and the basic scientist and deserves some further attention (Benini & DeLeo, 1999, p. 2119). The experience of pain may activate the goal to control or prevent (further) harm giving rise to a plethora of goal-directed actions. This goal however does not occur in isolation, but in a context with multiple, competing goals, such as going out with friends (Crombez et al., 2012). Often, controlling or avoiding pain competes with the pursuit of these other goals. Indeed, one of the most debilitating consequences of being in pain, is that the goal to avoid pain interferes with other goals, and often results in the withdrawal of valued activities (Crombez et al., 2012). However, fear and avoidance behavior are rarely considered within a broad motivational context. Therefore, Crombez et al. (2012, p. 478) argue that "*the Fear-Avoidance models needs to more explicitly adopt a motivational perspective, one that is built around the organizing powers of goals and self-regulatory processes*". In the next section we elaborate on motivation and in particular goal competition before advancing to the incorporation of a motivational perspective in the Fear-Avoidance model.

Motivation

Motivation, goals, and the governance of human behavior

Motivation is considered an inherent characteristic of human behavior. Therefore, behavior should be described in reference to an end point or goal (Emmons, 1986; Ford, 1992; Tolman, 1925). According to the Oxford Dictionary (2010), motivation is "*a reason for acting or behaving in a particular way, a desire, willingness to do something, or enthusiasm*", whereas a goal is defined as "*the object of a person's ambition or effort, an aim, or a desired result"*. In essence, motivation can be described as a process involving factors that energize, instigate, and direct—or simply *influence*—human behavior (Elliot & Covington, 2001; Jensen, Nielson, & Kerns, 2003), whereas goals are the desired future states people work to keep, achieve, or avoid (Austin & Vancouver, 1996; Kruglanski, 1996).

Several forms of motivations can be discerned. One of the most basic distinctions is that between intrinsic and extrinsic motivation: the forming meaning that doing something is motivating because it is inherently interesting or pleasant, and the latter referring to an external stimulus or outcome resulting in a drive to perform a certain behavior (Ryan & Deci, 2000). Another important distinction in the context of this dissertation is based on the theorem that human behavior is in essence guided by avoidance of pain and approaching pleasure, commonly known as the hedonic principle (*for an overview, see* Elliot & Covington, 2001; Elliot, 2008; Higgins, 1997). As Jeremy Bentham in 1789 eloquently stated in his Introduction to the Principles of Morals and Legislation: "*Nature has placed mankind under the governance of two sovereign masters, pain and pleasure. It is for them alone to point out what we ought to do, as well as to determine what we shall do."(p.1).* Indeed, from an evolutionary perspective, it is crucial for survival that organisms adequately determine whether stimuli signal potential (physical) harm, and move away from them, and likewise, approach stimuli that signify potential benefits, such as mates, or food (Schneirla, 1959, 1965; Tooby & Cosmides, 1990).

The hedonic principle is—or at least was—one of the most prominent concepts to explain and understand motivation in psychology (of learning): many researchers incorporated "avoidance" and "approach" in their theories. For example, in 1890, the American founding father of psychology William James proposed that pain and pleasure both were "*reinforcers*" of behavior, albeit in different ways: while pleasure enhances behavior, pain functions as an inhibitor (*see also* Elliot & Covington, 2001, p. 75). Konorski (1967) described that actions in response to a motivationally salient stimulus (US) or cues (CSs) predictive of these salient stimuli could be classified as *consummatory*—that is, specific to the actual outcome—or *preparatory*, which are actions related to the valence of the outcome, that is: withdrawal from stimuli resulting in negative consequences, and approaching stimuli

resulting in positive consequences (Seymour & Dolan, 2008, p. 662). Thorndike (1911, 1927) stated in his "Law of Effect" that actions leading to a "satisfactory state" will increase, whereas actions leading to negative consequences or discomfort will diminish (*see also* Domjan, 2005, p. 137). These are only a few examples demonstrating that the avoidance of pain and the approach of pleasure has been widely used to explain changes in behavior.

Note however that merely employing the hedonic principle is insufficient to explain human behavior in terms of motivation, and other explanatory principles should be considered (*For an overview, see* Higgins, 1997). One such principle is regulatory anticipation. In essence, this principle can be summarized as approaching anticipated, hoped-for desired end-states and avoiding feared, undesired end-states (Higgins, 1997, p. 1293). Andrew Elliot speaks of a distinction between approach and avoidance motivation, where *approach motivation* refers to behavior instigated and directed towards positive stimuli (events, objects, possibilities), whereas *avoidance motivation* concerns (moving away from) negative stimuli (Carver & Scheier, 1999; Elliot & Covington, 2001; Elliot, 1999, 2006). Put otherwise, approach and avoidance motivation can be described in terms of stimuli "*an animal will work to achieve or avoid*" (Leknes & Tracey, 2010, p. 1). By employing this description, the focus shifts from more hedonistic aspects to more behavioral elements of motivation (Leknes & Tracey, 2010). In this respect, pain—whether it is experimentally induced or not—can be considered a stimulus installing avoidance motivation, whereas rewards installs approach motivation.

Goals and intergoal relations: goal facilitation and goal interference

Central to all these different forms of motivations are goals. As indicated previously, goals can be conceptualized as the desired end-states people strive for (Austin & Vancouver, 1996; Gebhardt, 2006). In order to achieve these desirable end-states, people compare their current situation (actual state) to their desired end-state. In case there is a discrepancy between the actual and desired situation, they select behaviors that brings them closer to achieving their goals (Carver & Scheier, 1982; Gollwitzer & Oettingen, 1998). Consecutively, the outcome of behavior provides information on the progression towards the goal. Kruglanski (1996) therefore conceptualized goals as knowledge structures, containing information on the expected outcome of their attainment (*see* Gebhardt, 2006, p. 30). Over the years, personal goals have been studied extensively, albeit in different forms. Klinger (1977) spoke of "*current concerns*", referring to a commitment at a specific point in time to an action/plan until that action/plan is realized or abandoned; Little (1983) introduced the "*personal projects*", referring to goal-directed actions, whereas Emmons (1986) considers "*personal strivings*", that is, actions people try to undertake in their life.

One often heard criticism however, is that goals and behavior are regarded in isolation (Abraham & Sheeran, 2003; Gebhardt & Maes, 2001). Typically, multiple goals are active

simultaneously. Take for example a graduate student who wants to be an excellent researcher, to defend his/her PhD thesis well, to overcome fear of public speaking, to network, to be friendly, to spend more time with family and friends, to be healthy, and so on. When the pursuit of one goal has no impact on the pursuit of another goal, goals are considered to be independent. However, goals may also critically influence each other either positively (facilitation) or negatively (interference; Boudreaux & Ozer, 2012; Little, 1983; Riediger, 2007; Riediger & Freund, 2004). *(Inter)Goal facilitation* occurs when pursuing one goal also helps the attainment of another goal. Two forms of intergoal facilitation can be discerned: (1) instrumental relations: getting closer to attaining one goal may also result in progression towards another goal. For instance, regularly giving presentations about research may help our graduate student tackle his/her fear of public speaking, while it might simultaneously boost confidence for his/her PhD defense; and (2) overlapping goal-attainment strategies: engaging in one action helps making progress towards multiple goals. For example, engaging in regular exercise might provide an excellent opportunity to spend more time with friends, while simultaneously maintaining or improving health status.

In contrast, *(inter)goal interference or goal conflict*[1] occurs when the pursuit of one goal hinders the attainment of another goal. This interference may arise as a result of resource constraints, such as time, e.g., spending more time on the job may mean the graduate student can spend less time with family, or may due to incompatible attainment strategies. In the latter case, goal competition arises when two goals are associated with incompatible responses (Boudreaux & Ozer, 2012; Riediger, 2007; Riediger & Freund, 2004). For example, when offered a piece of cake, one may want to refuse it in order to stay healthy and fit, but at the same time may want to accept it in order to be polite. Kurt Lewin (1935) stated that indeed, conflict could be characterized as a situation in which two simultaneous forces of approximately equal yet opposite strength guide behavior. Furthermore, these forces may critically depend on the *valence of the outcome* (Diederich, 2003; Gray, 1975). When focusing on the valence of the outcome, taking away or non-presentation of a positive stimulus and presentation of a negative stimulus are functionally equivalent, as are non-presentation or abating a negative stimulus and presentation of a positive stimulus (McNaughton & Corr, 2004)[2]. Typically, an individual works to avoid negative outcomes, and tries to achieve positive ones. Accordingly, three different types of goal competition can be discerned (Epstein, 1978; Lewin, 1935; Miller, 1944; Murray, 1975; Sincoff, 1990). A first type of competition arises when an individual is presented with a

[1] Note that throughout this dissertation, the terms (inter)goal interference, goal conflict, and goal competition are used interchangeably.

[2] This view differs slightly from the terminology of avoidance and approach motivation (cf. infra), which revolves around the *valence of the stimulus* rather than the outcome inducing either approach (positive) or avoidance (negative) behavior.

situation in which two positive or desirable outcomes install approach tendencies in opposite directions. This is termed *approach-approach* competition. For example, the graduate student might want to attend a networking dinner party, but at the same time go to the movies with friends. A second type of competition may arise when the individual is hemmed in by negative outcomes, all installing avoidance tendencies. For instance, choosing between missing a deadline or sending in an incomplete or less optimal version of a manuscript. This is termed an *avoidance-avoidance* competition. A third type of competition arises when one situation/event/place is associated with both a positive and a negative outcome, installing simultaneous approach and avoidance tendencies, referred to as *approach-avoidance* competition. For instance, the graduate student may wish to go to a networking gala because of the opportunity to network, but may also want to avoid it because it makes him/her anxious. It is also possible that two events are both associated with a positive and negative outcome. Consequently, both events install tendencies to approach and to avoid. This situation is referred to as a *double approach-avoidance* conflict.

The study of these different types of goal interference has a long history in experimental-behavioral research (e.g., Hovland & Sears, 1938; Miller, 1944). When confronted with two or more competing goals, an individual often has to prioritize one goal over the other (Boudreaux & Ozer, 2012). However, experiencing conflict typically invokes "conflict behavior", reflected by oscillatory responding, or an indecisiveness on which goal to pursue. Indeed, being confronted with goal competition is inherently associated with making choices. There are however differences between competition types in the difficulty of selecting an action/goal (Eccles & Wigfield, 2002; Higgins, 2002; Roy, 2010). The earliest theories on these different types of goal conflict distinguished between situations where one competing response becomes dominant over the other by either increasing its own strength or decreasing the strength of the other, called unstable equilibrium, and situations in which responses reduce their own strength or increase that of their competitors once they are started, which is termed stable equilibrium (Lewin, 1935; Miller, 1944). Both Lewin (1935) and Miller (1944) proposed that approach-approach conflicts take place in unstable equilibrium, whereas avoidance-avoidance and avoidance-approach conflicts take place in a stable equilibrium. As a consequence, they both predicted that in general, approach-approach competition should be easy to solve and result in little oscillation. Avoidance-avoidance competition however, poses a greater difficulty, and individuals should try to escape from these situations. If escape is impossible, it should take participants longer to solve their conflict. Approach-avoidance situations would similarly be characterized by hesitancy and oscillation, although not as strong as in avoidance-avoidance competition (Murray, 1975). Several studies with human subjects have corroborated these assumptions. Hovland and Sears (1938) for example instructed one group of participants to move towards the flashing light (approach), and another group to move away from the flashing light (avoid). Two other groups were instructed to move towards one light, and avoid the other based on location or

color of the light. In the test phase, all lights were lit simultaneously creating approach-approach conflict in the first group, avoidance-avoidance conflict in the second group, and approach-avoidance conflict in the two remaining groups. The results indeed showed more hesitant behavior in the avoidance-avoidance group compared to the approach-approach group, with approach-avoidance groups situated in between. Barker (1942) found a similar difference between approach-approach and avoidance-avoidance conflict when repeatedly presenting tender age boys with either two liked, two disliked, or two relatively neutral drinks to choose from (*For a more detailed overview of experimental studies on goal conflict, see* Miller, 1944). Building on more general theories of decision-making (Broadbent, 1971), it has been suggested that the difficulty to solve a conflict can be measured by the time needed to select one option. In his experimental work, Murray (1975) used this 'conflict resolution time' as the primary indicator of conflict strength. In his experiments, Murray presented undergraduate students with a forced choice between two pairs of options that both contained positive elements, negative elements, or positive and negative elements. He recorded the time needed to make a decision, and observed similar patterns as described above (Murray, 1975). More recently, Diederich (2003) showed that when making decision under uncertainty in an experiment with multi-attribute choice options, decision time can be considered an index of conflict strength, and critically depends on the desirability and variability of the outcomes.

Goal interrelations—and more specifically, competition among goals—can also be assessed using self-report methods. Research on assessment of intergoal relations has shown that interference and facilitation can best be viewed as two separate effects, and as such, should be measured using a unipolar approach (Riediger, 2007). Most measures employing a unipolar approach (such as the personal project analysis of Little (1983) or the Intergoal Relations Questionnaire (IRQ) of Riediger and Freund (2004)) first ask participants to generate a number of personal goals, and consequently request them to assess goal interference and facilitation for each combination of goals. Like more experimental work on different types of goal conflict, research using self-assessment has demonstrated that avoidance-avoidance competition evokes more hesitation and oscillation than approach-approach competition, with approach-avoidance competition situated in between (Boudreaux & Ozer, 2012; Emmons & King, 1988).

Furthermore, it has repeatedly been theorized that the experience of goal conflict is associated with negative experiences (Riediger, 2007). There is experimental evidence suggesting that goal interference is negatively associated with goal attainment: the more interference individuals experience, the more individuals tended to spend time thinking about rather than acting on their goals (Carver & Scheier, 1990; Emmons & King, 1988; Kehr, 2003). Empirical research however does not clearly demonstrate that, as a consequence of the unsuccessful or hampered goal attainment, goal interference negatively impacts subjective well-being. In general, research indeed largely demonstrates

that the more goals compete, the poorer the well-being (Emmons & King, 1988; Palys & Little, 1983; Pomaki, Maes, & ter Doest, 2004; Riediger & Freund, 2004; Sheldon & Kasser, 1995), but these potentially detrimental effects of goal conflict on well-being were not always replicated (Kehr, 2003; Segerstrom & Solberg Nes, 2006). Kelly, Mansell, and Wood (2011) even reported that people experiencing less conflict had the most depressive symptoms.

(Chronic) Pain in a motivational framework

Despite the impact of goal competition on daily life and well-being, little is known about the effects of goal competition when being confronted with (persistent) pain. Notwithstanding the important theoretical and clinical implications of incorporating a broad motivational dimension to study chronic pain, research investigating the influence of competing goals on pain-related fear and associated defensive responding, such as avoidance behavior, is scarce (Crombez et al., 2012; Schrooten, Vlaeyen, & Morley, 2012). Cross-sectional research for example demonstrated that goal conflict was associated with more pain-related fear (Karoly, Okun, Ruehlman, & Pugliese, 2008), and with a greater increase in pain from morning to evening (Hardy, Crofford, & Segerstrom, 2011). Furthermore, it was even demonstrated that pain patients experience more goal frustration as well as goal conflict than control participants (Karoly et al., 2008). Only recently, an experimental approach has been employed indicating that a competing approach goal may attenuate avoidance behavior (Van Damme, Van Ryckeghem, Wyffels, Van Hulle, & Crombez, 2012). This project wishes to further our understanding of the impact of context (such as motivation) on pain-related fear and associated avoidance in experimental as well as in clinical situations.

First, we present a case[3] based on our interviews before outlining how the Fear-Avoidance model can be reframed in motivational terms and discussing treatments already incorporating motivational strategies to tackle pain-related fear and avoidance behavior. This introduction ends with an overview of the project aims and research lines.

> *Hanna is a 45 years old married woman that was diagnosed with chronic low back pain 10 years ago. Despite undergoing medical treatment, the pain persisted, and became even worse over time. When describing her life, Hanna often refers to two periods: her life before and her life after pain. Before she was diagnosed, Hanna was working as a nurse in a retirement home, took care of her household and her two kids (e.g., driving them to school, soccer practice), played volleyball, played keyboard in a band, and still managed to find time to spend quality time with her husband, and to go on regular shopping sprees with her sister and*

[3] To ensure anonymity, we used a fictitious name and left out or changed some of the details.

her friends. She prided herself in being (financially) independent, orderly, a good wife/friend, and having a good physique. Now, Hanna feels the pain hinders her in doing what she loves and wants to do. Hanna gave up her job 6 years ago, because she felt that she could not concentrate as well because the pain became worse. Although Hanna would love to go out more (to go shopping, play volleyball), she feels she has to cancel regularly, because it would cause her too much pain. Since she left her job, Hanna watches more TV and takes more regular breaks, reportedly all because of her pain. However, spending quality time with her husband is still part of her daily life. Hanna gave the following example "Often, when my friends call to ask me to go shopping with them, I have to refuse. I just cannot risk the pain to get worse. I would love to have fun with them, but…walking around, carrying bags, it just puts too much strain on my back. If I would do it, and the pain gets worse, that is the end of everything. That means sitting in the couch or lying in bed more than I already do, and I really do not want that…[…] How about spending quality time with your husband?...Well, my pain already puts a lot of strain on our relationship, as Tom has to help out more in the house because I cannot do it anymore. He is so sweet and takes such good care of me. I think he really deserves it, even if it means a bit more pain than I would normally have."

Reformulating the Fear-Avoidance model of chronic pain

As the example above illustrates, pain can be perceived as highly threatening and disruptive (Eccleston & Crombez, 1999). When in pain, an individual may wish to control or preferably prevent (further) harm whilst simultaneously pursuing other, normative daily tasks. These activities or goals may however be incompatible, which may bring about goal conflicts (Boudreaux & Ozer, 2012; Riediger & Freund, 2004). As a consequence, people with chronic pain often weigh the costs and benefits of pain avoidance against those of other valued activities (Gandhi, Becker, & Schweinhardt, 2013; Roy, 2010; Talmi, Dayan, Kiebel, Frith, & Dolan, 2009; Van Damme et al., 2012). In Hanna's case for example, (the prospect of) pain is pitted against the joy of going shopping with friends or spending quality time with her husband.

To take into account these dynamics, the two cognitive-behavioral responses or pathways described by the Fear-Avoidance model can be reframed in motivational terms (Crombez et al., 2012; Lauwerier et al., 2012; Van Damme, Crombez, & Eccleston, 2008). On the one hand, the pathway of misinterpretation of pain may be recast as the prioritization of the goal to control or avoid pain at the cost of other goals. Indeed, one of the most debilitating consequences of being in pain, is the withdrawal of other, valued activities (Crombez et al., 2012). For example, Hanna refrains from going shopping with friends, because she wants to avoid an increase in pain. The confrontational pathway on the other hand may correspond with the prioritization of other goals, despite pain, for example Hanna prioritizes quality time with her husband over pain control.

Employing a broad motivational account of the Fear-Avoidance model might help gain insight as to why some individuals might (excessively) engage in pain avoidance behavior, whereas others choose to stay active. As Hanna's case demonstrates, the importance of each individual goal or activity might lead to a certain decision. When controlling or avoiding (further) harm is considered highly important—instigated by a dysfunctional belief of a pending catastrophe and fear, or not—and systematically outweighs the importance of other life goals, it may contribute to prolonged avoidance and may result in disability.

Treatments of chronic pain including motivation

Although the role of motivational dynamics are poorly understood in the context of pain, several pain treatment strategies focus on both pain reduction/control goals as well as other daily life goals such as engaging in sports. Looking at chronic pain treatments from a broad motivational perspective, treatments (components) that focus on goal intention, and treatments (components) that focus on goal realization can be differentiated (Schrooten, Vlaeyen, et al., 2012). Treatments aimed at goal intention typically explore benefits and costs of both pain control and other daily life tasks or goals. Eventually, these treatments strive towards a resolution of patients' ambivalence and a more flexible pursuit of goals. In Exposure in Vivo for example, (fearful) participants receive education on the Fear-Avoidance model, how their interpretations and responses may contribute to their pain, often resulting in a more nuanced view of their problem and openness towards physical activity, despite pain (Schrooten, Vlaeyen, et al., 2012; Vlaeyen, de Jong, Geilen, Heuts, & van Breukelen, 2002). Another example of such a treatment is Motivational Interviewing. In Motivational Interviewing, the autonomy of patients is maximized, and the therapist tries to help patients identify important goals, re-evaluate importance of goals, find confidence to handle discrepancies between their current state and their goals or between goals, and formulate a readiness to change, that is, engaging in physical activity (Ang, Kesavalu, Lydon, Lane, & Bigatti, 2007; Jensen et al., 2003; Jones, Burckhardt, & Bennett, 2004; Miller & Rollnick, 2002; Schrooten, Vlaeyen, et al., 2012). Similarly, Contextual Cognitive-Behavioral treatment strategies such as Acceptance and Commitment Therapy focus on values an individual patient considers to be important, and derive goals—and intentions—from these values (McCracken & Yang, 2006; Schrooten, Vlaeyen, et al., 2012; Vowles & McCracken, 2008). In Hanna's case, treatment may help her understand that her fear of pain exacerbation and the possible catastrophe (cf. "*If I would do it, and the pain gets worse, that is the end of everything")* hinders her in what she values. Together with the therapist, Hanna can look back at what she values in life, such as being a good friend, and can list how staying at home versus going shopping with her friends benefits and/or hinders her, possibly leading to a preparedness to engage in the previously avoided activity.

When there is an intention to change, treatment may shift focus towards the realization of this intention. The main aim of these treatments is to provide disconfirmation of false beliefs, a successful experience, and improvement of general functioning despite pain and attaining valuable goals. In the

behavioral experiment component of Exposure in Vivo, patients engage in several feared activities, starting with the least feared activity and building up to the most feared activity. Typically, patients learn that what they expected to happen does not occur or is not as bad as they thought it would be (Leeuw et al., 2008; Schrooten, Vlaeyen et al., 2012; Vlaeyen et al., 2002). Another approach aimed at improving patients' activity level is Graded Activity, in which physical activity is gradually increased over time using a predetermined scheme of sessions and activity quota (Leeuw et al., 2008; Macedo, Smeets, Maher, Latimer, & McAuley, 2010). Hanna may for example start with short walks, carrying a bag to build up to a 'shopping trip' with her friends.

Project outline and research aims

Despite the increasing integration of motivational strategies in chronic pain treatments, our knowledge of the impact of motivation, and more specifically, competing goals, is limited. This project wishes to address this gap in literature. The overall aim of the current dissertation was to investigate how motivation impacts on pain-related fear and avoidance behavior, and to shed light on how individuals respond to conflict engendered by goal-directed behavior in the prospect of an aversive cost. By building on and expanding existing experimental fear conditioning paradigms—that is, the Voluntary Joystick Movement Paradigm (e.g., Meulders et al., 2011)—we wanted to assess how pain-related fear and avoidance behavior are affected by concomitant goals and goal conflicts. In a related vein, we wanted to systematically map the presence of goal conflict-experiences in a clinical population, and explore whether patients and controls differ in the perception of conflict. We address these questions in four parts. In part I (Chapter I.1 and I.2), we discuss two experiments investigating the impact of introducing a competing goal—operationalized as a concurrent reward—on pain-related fear and defensive responding in a healthy population. In part II (Chapter II.1), we discuss the differential impact of various types of goal competition on pain-related fear and avoidant decision-making. In part III (Chapter III.1 and III.2), we describe two experiments investigating the impact of context cues predicting pain versus reward on pain-related fear and avoidance behavior. Part IV (Chapter IV.1) delineates a clinical observational study investigating the phenomenology of goal conflict in a patient sample. Finally, we provide a summary of the findings, their theoretical and clinical implications, and discuss limitations and avenues for future research in the general discussion of this dissertation.

Part I: the impact of a competing approach goal on pain-related fear and avoidance behavior

Chapter I.1 Competing goals attenuate avoidance behavior, but not pain-related fear

In Study I.1, we investigated whether pain-related fear and avoidance behavior were attenuated when individuals were faced with a pain avoidance goal and a competing goal–operationalized as obtaining a monetary reward. Therefore, healthy participants moved a joystick towards different targets. In the experimental condition, a movement towards one target (CS+) was followed by a painful unconditioned stimulus (pain-US) and a rewarding unconditioned stimulus, which was operationalized as a lottery ticket to obtain 50 euros (reward-US), whereas another movement (CS-) was not. In the control condition, the CS+ movement was followed by the pain-US only. Response latencies and response durations were recorded during every movement trial. Self-reported pain-expectancy and pain-related fear were assessed prior to performing a movement. Participants also completed choice-trials, in which they could choose to perform either the CS+ or the CS- movement. Based on learning theories, we expected that the concurrent reward would result in a decrease of pain-related fear, as well as diminished avoidance behavior, as measured by choice behavior and response latencies. These findings may illustrate the impact of a competing approach goal—a concurrent reward—on pain responding, as well as provide further evidence for the validity of the VJM paradigm.

Chapter I.2 The impact of goal competition and goal prioritization on avoidance behavior and pain-related fear

This second experiment (study I.2) wished to replicate and expand the findings of study I.1, by investigating whether goal preference (goal prioritization) modulates the effect of a concurrent reward on pain-related fear and avoidance behavior. A similar differential human fear conditioning paradigm as in Study I.1 was used. Additionally, participants were classified in three groups, based on the goal they a priori reported to be the most important: (1) *pain-avoidance* (*n'* = 19), (2) *reward-seeking* (*n'* = 21), and (3) both goals being *equally important* (*n'* = 17). We wished to check whether pain-related fear would remain unaltered despite the reward—as was the case in Experiment I.1—and again hypothesized that avoidance behavior would be attenuated when presented with a concurrent reward. Furthermore, we expected that goal prioritization would further modulate the results, with pain avoiders more avidly avoiding the painful movement.

Part II: The effect of multiple goal conflicts on pain-related fear and avoidance behavior

Chapter II.1 An experimental investigation of the differential effects of various types of goal competition on defensive responding

Study II.1 wished to experimentally investigate the differential impact of various types of goal competition by using a cross-directional joystick movement task. Participants completed two instrumental acquisition phases and a multiple goal test phase. In the pain goal acquisition phase, participants learned which three movements were associated with a painful stimulus, and which three movements were safe. In the reward goal acquisition phase, participants similarly learned to associate different movements with either gain or loss of reward. In the test phase, both acquisition phases were combined. Movements could thus predict one or two of the different outcomes, creating different types of goal competition: approach-approach, avoidance-avoidance, and approach-avoidance. In the first part of the test phase, self-reported fear and eagerness, and willingness to perform a specific movement were recorded. Additionally, we presented participants with choice trials, in which two movements associated with different outcomes were presented. We recorded which movement participants wanted to perform in a later phase. Decision times were registered as well. In the second part, participants performed each of the movements twice. Response latencies and response durations were collected. We expected that avoidance-avoidance conflicts would be hardest to solve and would evoke the most fear and avoidance, whereas approach-approach conflicts would be easiest to solve and evoke the least fear and avoidance. We expected that approach-avoidance conflicts would be situated in between.

Part III: The impact of environmental cues predicting (dis)similar outcomes on pain-related fear and avoidance behavior

Chapter III.1 The impact of cues predicting pain versus reward on pain-related fear and avoidance behavior

In study III.1, we investigated whether environmental cues predicting a painful outcome increase pain-related fear and associated avoidance tendencies, whereas cues predicting reward would result in a decrease. The experiment comprised of an instrumental acquisition phase, a Pavlovian acquisition phase, and a test phase. In the instrumental acquisition phase, participants completed an experimental movement task in which they performed two different joystick movements. One movement was associated with a painful stimulus, the other was followed by a reward. In the subsequent Pavlovian acquisition phase, participants learned to associate three different Pavlovian cues (colored circles; CSs), with either the painful outcome, the rewarding outcome or neither of the two. In the test phase, these Pavlovian cues were integrated in the movement task. In a first part, the choice phase, participants were informed that they could choose if they would perform the depicted

movement in a later phase of the experiment. Choice and choice latency were registered. In the second part, in which participants performed movements, self-reported fear and eagerness were recorded, as well as response latencies and response durations. Additionally, participants were presented with trials in which two different movements were presented together with the same or different CSs, and participants chose and performed one of both movements. We hypothesized that cues predicting a similar, painful outcome would increase pain-related fear and avoidance behavior, whereas cues predicting a dissimilar (rewarding) outcome would result in a decrease of pain-related fear and avoidance. Such a pattern of results would demonstrate that pain-related responding can be influenced by environmental cues.

Chapter III.2 The impact of environmental cues on pain avoidance: a behavioral study

In Chapter III.1, we focused mostly on verbal indicators and choices as indices of avoidance behavior. In study III.2, we focused on the impact of environmental cues on free operant (avoidance) behavior. We again hypothesized that cues predicting pain would increase avoidance, whereas a reward cue would decrease avoidance behavior. The experiment comprised of five parts. First, participants completed an instrumental acquisition phase, in which they performed arm stretch movements using a pneumatic robot arm. Participants were requested to perform movements in three areas, associated with 80%, 50%, or 0% of receiving a painful stimulus, respectively. Next, participants completed an operant baseline phase, in which they chose which movement they performed. Third, a Pavlovian acquisition phase ensued, in which participants learned to associate CSs with either the painful outcome, receiving lottery tickets, or neither of both. Fourth, during the free test phase, the Pavlovian cues were integrated in the operant movement task. Participants again freely chose and performed arm stretch movements while the Pavlovian cues were presented. In this phase, we measured response latency, response duration, maximal movement distance, and chosen movement area. Lastly, in the restricted test phase, the movement area was restricted to the area associated with the highest chance of pain, in order to measure the force exerted to avoid this area.

Part IV: A systematic examination of goal conflict in chronic pain patients

For practical reasons regarding recruitment and efficiency, we combined the study described in chapter IV.1 together with another observational study and an experimental study of Annick De Paepe (Ghent University) in the Pain-Attention-Motivation Project 1 (PAM-I project). The main objectives of the observational studies were to (1) investigate whether and to what extent patients with fibromyalgia experience goal conflict between different activities, (2) whether there are differences between patients with fibromyalgia compared to healthy controls regarding the number, type, and experience of conflicts, and (3) whether there is an association between the experience of goal conflict and core constructs of the Fear-Avoidance model (e.g., pain-related fear, catastrophizing).

Chapter IV.1 The assessment of goal conflict in Fibromyalgia: a daily reconstruction method

In order to address the questions mentioned above, patients with fibromyalgia and matched healthy controls were invited for an individual session. Prior to this session, participants completed questionnaires focusing on sociodemographic information and core-concepts of the Fear-Avoidance model. During the individual appointment, they participated in a semi-structured interview based on the daily reconstruction method of Kahneman, Kreuger, Schkade, Schwarz, and Stone (2004). During this interview, participants first reconstructed their preceding day in a stepwise fashion. Consequently, the interviewer provided a definition of goal conflict in the context of the study, and asked participants to report on the conflicts experienced during the previous day. Next, participants classified each of the activities involved in each reported conflict into one of nine predefined goal categories. Subsequently, participants completed a small questionnaire on the characteristics of the experienced conflicts. Lastly, the experience of pain, fatigue, affect, and satisfaction with their day was assessed.

PART I:

The impact of a competing approach goal on pain-related fear and avoidance behavior

CHAPTER I.1

Competing goals attenuate avoidance behavior, but not pain-related fear

Abstract

Current Fear-Avoidance models consider pain-related fear as a crucial factor in the development of chronic pain. Yet, pain-related fear often occurs in a context of multiple, competing goals. This study investigated whether pain-related fear and avoidance behavior are attenuated when individuals are faced with a pain avoidance goal and another valued but competing approach goal, operationalized as obtaining a monetary reward. Fifty-five healthy participants moved a joystick towards different targets. In the experimental condition, a movement to one target (Conditioned Stimulus; CS+) was followed by a painful unconditioned stimulus (pain-US) and a rewarding unconditioned stimulus on 50% (reward-US) of the trials, whereas the other movement (CS-) was not. In the control condition, the CS+ movement was followed by the pain-US only. Results showed that pain-related fear was elevated in response to the CS+ compared to the CS- movement, but that it was not influenced by the reward-US. Interestingly, participants initiated a CS+ movement slower than a CS- movement in the control condition but not in the experimental condition. Also, in choice trials, participants performed the CS+ movement more frequently in the experimental than in the control condition. These results suggest that the presence of a valued competing goal can attenuate avoidance behavior.

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Introduction

A wealth of evidence endorses the role of pain-related fear in the development and maintenance of (chronic) pain problems (Gheldof et al., 2010; Jensen, Karpatschof, Labriola, & Albertsen, 2010; Leeuw, Goossens, et al., 2007; Turk & Wilson, 2010; Van Damme et al., 2012; Vlaeyen & Linton, 2000; Wideman, Adams, & Sullivan, 2009). Recently, it has been suggested that pain-related fear should be considered within a motivational context. More specifically, the experience of pain not only might lead to the development of pain-related fear, but may also activate the goal to control or avoid (further) harm (Crombez et al., 2012; Leeuw, Goossens, et al., 2007; Van Damme et al., 2008; Van Damme, Legrain, Vogt, & Crombez, 2010). However, the goal to avoid pain does not occur in a motivational vacuum (Crombez et al., 2012; Leeuw, Goossens, et al., 2007; Van Damme et al., 2008; 2010). Indeed, to avoid bodily harm or pain is often only one goal in a context of other, often competing, goals (Christiansen, Oettingen, Dahme, & Klinger, 2010; Crombez et al., 2012; Karoly et al., 2008; Karsdorp & Vlaeyen, 2011; Schrooten & Vlaeyen, 2010; Van Damme et al., 2008; Verhoeven et al., 2010; Vlaeyen & Linton, 2000; Wiech & Tracey, 2013). In a context of multiple goals, the pursuit of one goal may possibly interfere with the pursuit of other goals. This may give rise to goal conflicts during which the same response elicits opposing outcomes (Boudreaux & Ozer, 2012). Previous research has shown that individuals with chronic pain often have to weigh the value of pain avoidance against the costs of withdrawal from previously valued activities (Gandhi et al., 2013; Roy, 2010; Talmi et al., 2009; Van Damme et al., 2012), and that they experience difficulties selecting which goal to pursue (Eccles & Wigfield, 2002; Higgins, 2002; Roy, 2010). Studies investigating the influence of competing goals on pain-related fear, avoidance behavior, and associated decision making behavior are scarce. Most experimental pain research on goals has focused on goal pursuit and attentional processes, indicating that pursuing nonpain goals can inhibit the attentional bias to pain (Karsdorp, Nijst, Goossens, & Vlaeyen, 2010; Van Damme et al., 2012; Verhoeven et al., 2010).

Although fear conditioning models are widely accepted as an experimental approach to investigate how fear is acquired, motivational factors have not yet been incorporated into these models (Craske, Hermans, & Vansteenwegen, 2006). A well-established paradigm to study the acquisition of movement-related fear of pain, is the Voluntary Joystick Movement (VJM) Paradigm (Meulders et al., 2011; Meulders & Vlaeyen, 2012, 2013a), which exemplifies a typical human fear conditioning experiment: a conditioned stimulus (CS+), that is, arm movements performed with a joystick, is followed by an aversive electrocutaneous stimulus, that is, painful unconditioned stimulus (pain-US). After repeated pairings with the US, the CS+ becomes a threat signal, and thus starts to elicit fear responses (conditioned response, CR). In a differential fear conditioning paradigm, a control stimulus (CS-) is included that is never followed by the US, and thus becomes a safety-signal (Domjan, 2005).

In the present study, we adapted the VJM paradigm to experimentally create goal competition by introducing lottery tickets representing a monetary reward as a reinforcing US, to investigate whether pain-related fear and avoidance behavior are attenuated when individuals are confronted with a pain avoidance goal and a competing goal, that is, obtaining the reward. In the control condition, a movement towards one target (CS+) was followed by a painful stimulus (US), whereas another movement (CS-) was not. In the experimental condition a rewarding conditioned stimulus (reward-US) accompanied the pain-US, thus installing competition between an inclination to avoid pain and an inclination to obtain a reward. We hypothesized that a concurrent reward-US would lead to 1) reduced fear responses, i.e., less self-reported pain-related fear for a painful (CS+) movement, 2) less avoidance tendencies, i.e., lower response latencies for CS+ movements in the experimental condition, and 3) less avoidant decision making behavior, i.e., choosing to perform the painful movement instead of the safe movement. Additionally, we explored whether the importance of both the pain-avoidance and the approach-reward goal was associated with participants' decision making behavior.

Methods

Participants

Fifty-five healthy individuals (28 men, M_{age} = 21.62, SD_{age} = 3.45) volunteered. Ten participants (18%) were left-handed. Participants were recruited by means of flyers distributed at the KU Leuven, advertisements (both online and on paper), and via the Experiment Management System (EMS) of the Faculty of Psychology and Educational Sciences of the KU Leuven (Belgium). Participants either received course credits or € 10 for their participation. Exclusion criteria were insufficient knowledge of the Dutch language, dyslexia, cardiovascular diseases, lung diseases, neurological diseases (e.g., epilepsy), other serious medical conditions, current diagnosis of psychiatric disorders, chronic or acute pain, being asked to avoid stressful situations by a general practitioner, presence of electronic medical devices (e.g., pace-maker), anxiolytics or antidepressants, pregnancy, and deteriorated vision that is not corrected.

Participants received information, both orally and in writing, that painful electrocutaneous stimuli would be administered, but that the intensity of the stimulus would be individually selected. Participants were given the opportunity to ask for additional information. All participants provided a written informed consent. Ethical approval was obtained through the Ethics Committee of the Faculty of Psychology and Educational Sciences of the KU Leuven (Belgium), registered no. S55216. Because of a technical failure, three participants did not receive any electrocutaneous stimulus during the experiment. Two other participants did not adhere the experimental instructions, and thus their responses were unreliable. These 5 participants were excluded from the statistical analyses. Statistical analyses were conducted on a sample of 50 participants (26 male; M_{age} = 21.36 years, SD_{age} = 3.28; 20% left-handed).

Apparatus and stimuli

The experiment was run on a Windows XP computer (Dell OptiPlex 755; Dell, Round Rock, TX) with 2 GB random-access memory (RAM) and an Intel Core2 Duo processor (Intel, Santa Clara, CA) at 2.33 GHz and an ATI Radeon 2400 graphics card (Advanced Micro Devices, Synnyvale, CA) with 256 MB of video RAM. The experiment was programmed in Affect, version 4.0 (Spruyt, Clarysse, Vansteenwegen, Baeyens, & Hermans, 2010). An electrocutaneous stimulus of 20 ms duration served as the pain-US. The pain-US was delivered by an Isolated Bipolar Current Stimulator (DS5; Digitimer ltd, Welwyn Garden City, England) through surface SensorMedics electrodes (1 cm diameter; SensorMedics Corp, San Diego, CA) filled with K-Y gel (Johnson & Johnson, New Brunswick, NJ) that were attached to the wrist of the dominant hand. The stimulus intensity was individually determined during a preexperimental calibration procedure, selecting a stimulus at tolerance level. A monetary reward in the form of lottery tickets (reward-US) was introduced in the experimental condition. A single reward-US always represented two lottery tickets. These lottery tickets represented a chance to win an extra € 50 reimbursement. Movements performed using a Paccus Hawk Joystick (Paccus Interfaces BV, Almere, The Netherlands) in four different directions served as CSs (i.e., towards the left, right, upward or downward). Participants carried out the movements with their dominant hand. Direction of movement was either indicated by a signal (by a purple coloring of a target) or chosen by the participant. The pain-US with or without the reward-US is delivered after completion of a movement in one direction (CS+) but not in another direction (CS-).

Self-report measures

Manipulation check

To check whether participants successfully learned the contingencies, participants reported online prior to the movements to what extent they expected the pain-US to occur ("pain expectancy"). Therefore, a scale ranging from 0 (not at all) to 10 (very much) was used.

Outcome measures

The primary goal of this experiment was to investigate whether a concurrent reward was capable of attenuating pain-related fear. Therefore, we asked participants to indicate to what extent they were afraid that the movement would be painful ("pain-related fear") before performing that movement.

Secondly, the current experiment aimed to explore whether there are any changes in pain intensity, pain unpleasantness, or pain tolerance when adding a concurrent reward to a painful movement. Therefore, participants reported retrospectively to what extent the electrocutaneous stimulus was painful ("pain intensity"), unpleasant ("pain unpleasantness"), and tolerable ("pain tolerance"). Participants answered all these questions using a 11-point Likert-scale, ranging from 0 (not at all) to 10 (very much).

Additional measures

Additional items were included to explore the role of goal importance on avoidance behavior. Participants indicated how important they found the two goals during the experiment using a Likert scale ranging from 0 (not at all important) to 10 (very important). The questions were *"How important was it to avoid the electrocutaneous stimulus?" ("pain-avoidance") and "How important was it to earn tickets?"("approach-reward"),* respectively.

Questionnaires

For descriptive purposes, participants completed several questionnaires: the Dutch version of the Pain Catastrophizing Scale (PCS; Van Damme, Crombez, Bijttebier, Goubert, & Van Houdenhove, 2002), which consists of 13 items and measures the frequency of catastrophizing thoughts and feelings generally experienced during painful situations; the Fear of Pain Questionnaire (FPQ-III NL; Van Wijk & Hoogstraten, 2006), which measures fear associated with pain in general and consists of 31 items; and the trait version of the Positive Affectivity and Negative Affectivity Scale (PANAS), asking participants to indicate how frequently they experience each of 20 adjectives describing both positive and negative emotions (Engelen, De Peuter, Victoir, Van Diest, & Van Den Bergh, 2006).

Behavioral measures

Response latency

For every movement, the response latency was recorded. As in previous studies (Meulders et al., 2011; Meulders, Vansteenwegen, et al., 2012; Volders et al., 2012), response latency is the time before onset/initiation of the joystick movement. More specifically, it was defined as the time from the disappearance of the fixation cross ('+') until participants left the start region, which is a relatively small, invisible circle around the fixation cross in the middle of the computer screen. Response latency is considered a proxy of avoidance tendencies (Chen & Bargh, 1999; Mineka & Gino, 1980).

Decision making behavior

Participants completed four choice test trials per condition, in which they chose between the CS+ movement and the CS- movement. This measure is taken as an index of approach/avoidance decision making behavior.

Procedure

The whole experimental session consisted of a calibration, a practice, an experimental and a debriefing phase and lasted about 75 minutes. A graphical overview of the experiment is presented in Figure I.1.1.

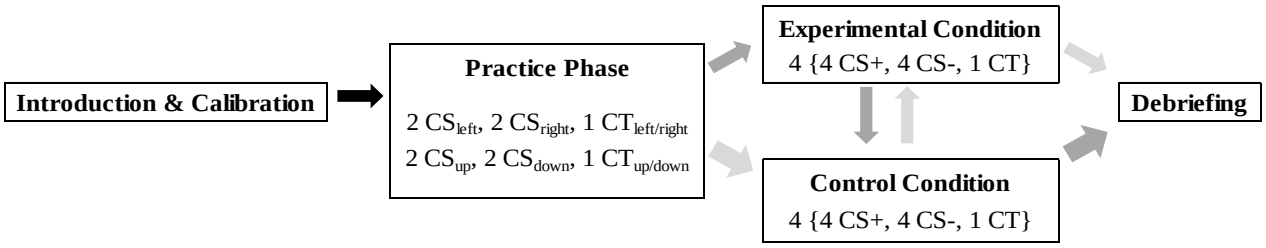

Figure I.1.1. Experimental Design. CS+ indicates reinforced movements that were followed either by both the pain-US and the reward-US (experimental condition), or by the pain-US alone (control condition) in 50% of the trials. In the practice phase, CS+ movements were never reinforced. CS- indicate non-reinforced trials, which were never followed by either of the USs; CT indicates choice trials, in which participants chose to perform either one of the movements. These trials always occurred at the end of a block. When choosing for the CS+ movement in these CTs, the trials were 100% reinforced. Movements were conducted in two movement planes (vertical and horizontal), and were counterbalanced between conditions. Conditions were run within subject in a counterbalanced order (cf. arrow). Also note that the last block in each condition served as a test block.

Calibration phase

Upon arrival, participants were seated in an armchair (0.6 m screen distance) in a sound-attenuated experimental room, adjacent to the experimenter's room. First, the electrodes for electrocutaneous stimulation were attached. Subsequently, the intensity level of stimulation was determined using a calibration procedure. Participants were informed that they would be repeatedly exposed to electrocutaneous stimuli of increasing intensity and that the aim was to select a painful stimulus that requires some effort to tolerate. At each trial, participants indicated (1) whether the stimulus was painful and required some effort to tolerate and (2) whether they agreed to receive a stimulus of increased intensity. Participants were also instructed to inform the experimenter when they no longer wished to increase the intensity or that the intensity had to be set back at a lower intensity. When no further increase of stimulus intensity was accepted, the experimenter asked the participant whether s/he agreed to repeatedly receiving stimuli of maximally the selected intensity during the remainder of the experiment. However, participants always received the same stimulus intensity, that

is, at tolerance level. Participants rated the pain intensity of the selected electrocutaneous stimulus right before the start of the experimental phase (M = 6.36, SD = 1.12).

Practice Phase

In the practice phase, participants learned how to operate the joystick correctly and familiarized themselves with the experimental task. Participants were instructed to move the joystick as fast and accurately as possible toward the signaled target as soon as the fixation cross (start signal, '+') disappeared. The to-be-performed movement was signaled by changing the color of the corresponding target from white to purple. A successful movement resulted in changing the color of the target to yellow. During the practice phase, no pain- and reward-USs were presented. Participants were informed they would receive feedback, both visually on screen and verbally from the experimenter. First, participants were able to monitor their own joystick movements via a cursor shown on the screen. Second, when participants performed a movement in the wrong direction, or left the starting region before the fixation cross disappeared, an error message was displayed (e.g., '*too early, please wait until the fixation cross disappears*'). The experimenter was present in the experimental room and provided tailored feedback if needed. Two blocks of 5 trials were run: the first block consisted of 2 signaled movements in both directions of the horizontal movement plane (left/right), followed by one choice trial in which participants had to choose and perform one of either movements. The second block was identical to the first block, the only difference being that the movements were performed in the vertical movement plane (upward/downward). Each trial started with a 1.5 s presentation of the fixation cross, and ended when the participant reached the target with his/her movement. A next trial started 10 seconds later (Inter-Trial Interval [ITI] = 10 s). For an overview of the trial timing, see Figure I.1.2.

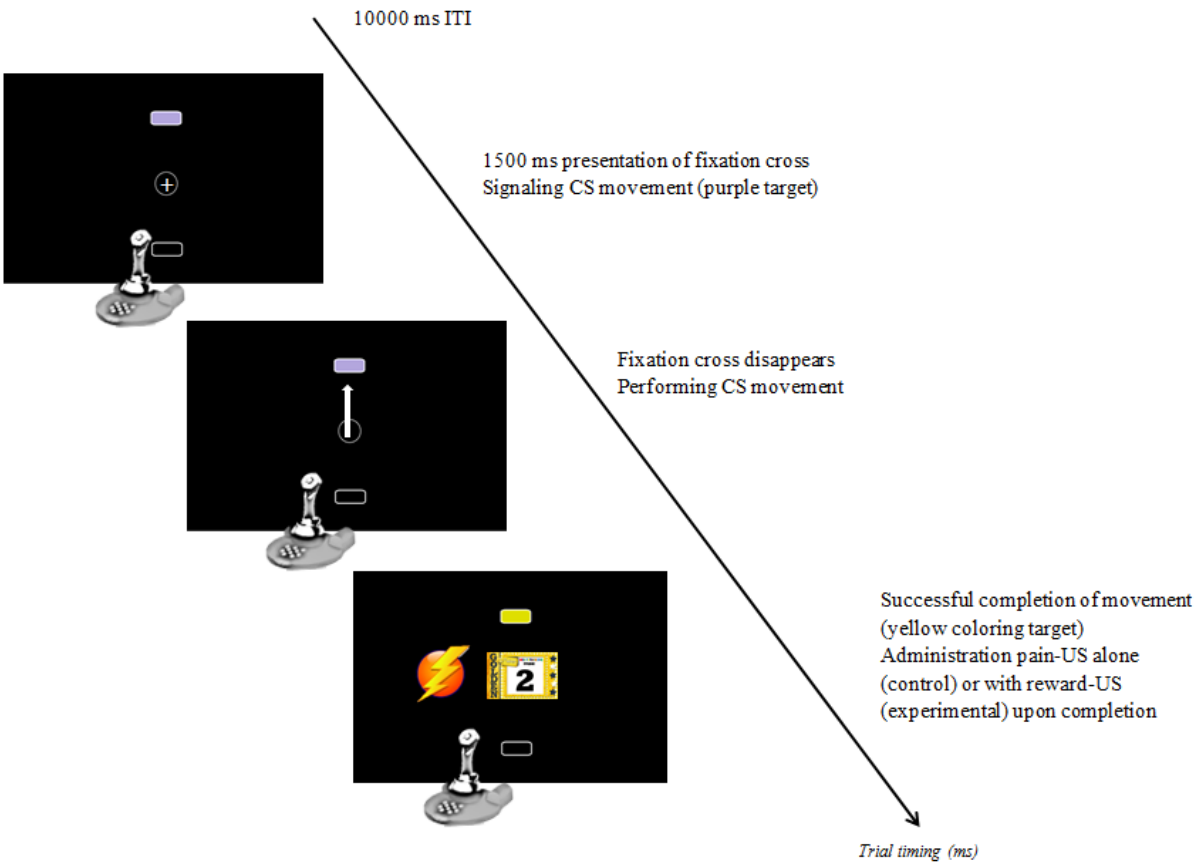

Figure I.1.2. Overview Trial Timing. Note that the conditions took place in a different movement plane, for example, the control condition in the horizontal movement plane and the experimental condition in the vertical movement plane. Which movement participants had to perform was signaled by a purple-colored target. Thus, the position of the CS+ movement differed between conditions. In the control condition, reinforced CS+ movements were followed by a pain-US in 50% of the trials, represented by a lightning bolt; whereas in the experimental condition CS+ movements were reinforced in half of the trials by a pain-US and a reward-US, as represented by the lottery ticket. In both conditions, CS- movements were never reinforced. An arrow indicates the CS movement. Successful completion of the CS movement resulted in coloring the target yellow.

Experimental phase

Before the start of the experimental phase, the pain-US was administered once more, and participants rated the pain intensity. We employed a cross-over within-subjects design with all participants completing both the control and the experimental conditions. The order in which the conditions were completed was counterbalanced. Participants manipulated a joystick to the left and to the right (horizontal movement plane) in the experimental condition, and upward and downward (vertical movement plane) in the control condition, or vice versa. At the start of each condition, participants were informed that they would have to perform the signaled movements as quickly and

accurately as possible as soon as the fixation cross disappeared, and were requested to pay close attention to the fixation cross.

In the ***experimental condition***, participants were informed that a movement in one direction (CS+) would be followed by an electrocutaneous stimulus (pain-US) and lottery tickets (reward-US), whereas a movement (CS-) in another direction would not. The reward-US always represented 2 lottery tickets. The experimenter explicitly stated that on some trials, participants were requested to perform the signaled movement, whereas on other trials, they could choose which of the two movements they performed. Participants were informed that the more tickets they earned during the task, the higher the probability that they would win the extra reimbursement of € 50. The participants first completed 4 acquisition blocks each consisting of 8 trials (4 CS+, 4 CS-). The last acquisition block served as the test phase. Each acquisition block was followed by one choice trial, in which they chose to perform either the CS+ or the CS- movement. Which particular movement served as a CS+ was counterbalanced across participants. There were no breaks between blocks. CS+ movements were immediately followed by the pain-US and the reward-US in half of the trials (50% reinforcement rate), whereas the CS- movement was never reinforced. That is, all participants received a total of eight reward-USs (representing 16 lottery tickets) and eight electrocutaneous stimuli in this phase. In the four choice trials, CS+ movements were always followed by both USs (100% reinforcement rate), whereas the CS- was never followed by either of the USs. Consequently, all participants could earn up to an additional eight lottery tickets in this phase. Trial timing was similar to the practice phase. At the end of each block participants rated pain intensity, pain unpleasantness and pain tolerance. Pain expectancy and pain-related fear were assessed once per block before the start of one CS+ movement and one CS- movement.

The ***control condition*** was identical to the experimental condition, with the only exception being that the CS+ movement was only followed by the pain-US. Participants were informed that in this phase, one movement would be followed by an electrocutaneous stimulus (pain-US), whereas another movement would not.

Debriefing

All participants were informed about the number of tickets that they had won, and were requested to leave their email address to be contacted in case they won the € 50. Second, participants were invited for a debriefing at which they were informed about the objectives of the experiment. At the end of the experiment, a winner was randomly selected out of all participants and informed about his prize.

Results

Data preparation

For each condition, we calculated the total number of times the CS+ was chosen as an index of decision making behavior (range = 0-4). When ratings from multiple time points for self-reported measures were available**,** mean scores were calculated**.** For response latency, outlier trials were excluded within each subject from further statistical analysis (<1%). Thus, response latencies < 250 and > 3000 ms were eliminated, as well as trials with response latencies deviating more than 3 SDs from the within-subject-mean calculated for the corresponding movement (CS+/CS-) and condition (control/experimental; Meulders et al., 2011). Subsequently, mean response latencies for each CS movement per block, per condition were calculated for each participant by averaging the 4 movements of that block.

Data-analysis

All statistical analyses were run with SPSS 20.0 (SPSS, Chicago, IL). Repeated measures ANOVAs were run to test for the effects of the reward-US (competing goal; experimental condition) on decision making behavior, as well as on pain-related fear, pain intensity and response latencies during test trials. Greenhouse Geisser corrections are reported where necessary. Effect sizes were calculated using the dependent Cohen's *d* (Cohen, 1998). Power analyses using G* Power 3.1.7 (Faul, Erdfelder, Lang, & Buchner, 2007) indicated that a total of 50 participants would provide 93% statistical power for a medium effect size for repeated measures analysis.

Descriptive statistics

The average intensity of the painful stimulus was 9.46 mA (*SD* = 4.82). Participants earned on average 20.68 lottery tickets (*SD* = 3.28). The mean score for PCS was 19.16 (*SD* = 8.75), and for FPQ-III-NL 73.9 (*SD* = 14.12). Mean score was 35.69 (*SD* = 4.73) on the positive affectivity scale and 15.94 (*SD* = 5.26) on the negative affectivity scale of PANAS. There were no significant gender differences on either of these independent variables, nor did the current sample differ from other (student) samples of comparable age (Meulders et al., 2011).

Self-report measures

A series of 2 (Condition [Control/Experimental)]) × 2 (CS type [CS+/CS-]) Repeated Measures ANOVAs were conducted with self-reported measures (pain-expectancy, pain-related fear, pain-US intensity, unpleasantness and tolerance) as dependent variables (see Table I.1.1). For the *pain expectancy measure*, there was a significant main effect of CS type, $F(1,49) = 79.02$, $p < .001$, $d = 1.25$ [95% CI: 0.88, 1.62], indicating that participants learned that the CS+ movement was associated with the pain-US, whereas the CS- movement was not. There was no effect of Condition, $F(1,49) = 1.14$, $p = .291$, $d = -0.15$ [95% CI: -0.43, 0.013], nor a CS type × Condition interaction, $F < 1$.

For the *pain-related fear* measure, there was a significant main effect of CS type, $F(1,49) = 51.93$, $p < .001$, $d = 1.02$ [95% CI: 0.68, 1.36], no significant main effect of Condition, $F(1,49) < 1$, $p = .360$, $d = 0.13$ [95% CI: -0.15, 0.41], nor a significant Condition × CS type interaction, $F(1,49) = 1.126$, $p = .294$, $d = 0.15$ [95% CI: 0.13, 0.43]. This indicates that participants had elevated levels of pain-related fear in response to the CS+ compared to the CS-.

For the *pain intensity measure* statistical analysis revealed that there was no difference between conditions, $F(1,49) < 1$, $p = .523$, $d = -0.09$ [95% CI: -0.37, 0.19]. Finally, participants did not experience the painful stimulus as significantly less unpleasant when a reward-US was presented concurrently, compared to when only a pain-US was administered, $F(1,49) < 1$, $p = .330$, $d = -0.14$ [95% CI: -0.42, 0.14], nor did they rate the pain-US as less tolerable in the experimental condition compared to the control condition, $F(1,49) = 1.05$, $p = .310$, $d = 0.14$ [95% CI: -0.13, 0.42].

Table I.1.1

Mean and SD per CS type and Condition for all self-reported measures and response latency

		Control condition	Experimental condition
Variable	CS type	*M*(*SD*)	*M*(*SD*)
Expectancy	CS+	6.83(1.79)	6.77(1.79)
	CS-	2.77(2.71)	2.44(2.52)
Pain-related fear	CS+	6.06(1.82)	6.37(1.66)
	CS-	3.13(3)	3.16(2.83)
Pain intensity	CS+	6.36(1.59)	6.24(1.65)
Pain unpleasantness	CS+	7.02(1.6)	6.8(1.68)
Pain tolerance	CS+	5.88(1.75)	6.06(1.87)
Response Latency	CS+	501(177)	445(156)
	CS-	440(139)	446 (127)

Note. CS+ indicates the reinforced conditioned stimulus, and was thus followed by a Pain-US in the control condition and by both a Pain-US and a Reward-US in the experimental condition. CS- indicates the non-reinforced conditioned stimulus and was never followed by an US. Response latency is in ms.

Behavioral measures

Response latency

The mean response latencies for CS+ and CS- movements for both the experimental and the control conditions during the test phase are displayed in Figure I.1.3. A 2 (CS type [CS+/CS-]) × 2 (Condition [Experimental/Control]) Repeated measures ANOVA showed a marginally significant effect of CS type, $F(1,49) = 3.987$, $p = .05$, $d = 0.28$ [95% CI: -0.09, 0.56], as well as a significant effect of Condition, $F(1,49) = 5.009$, $p = .03$, $d = -0.31$ [95% CI: -0.6, -0.03]. Furthermore, the interaction CS type × Condition was significant, $F(1,49) = 4.60$, $p = .037$, $d = -0.30$ [95% CI: -0.59, -0.02]. Follow-up comparisons revealed that participants were slower initiating a CS+ movement than CS- movements in the control condition, $t(1,49) = -2.878$, $p = .006$, $d = 0.41$ [95% CI: 0.12, 0.70]. In the experimental condition however, no differences in response latencies for both CS movements were found, $t(1,49) = -.038$, $p = .970$ $d = 0.01$ [95% CI: -0.27, 0.28], suggesting that participants were less hesitant to perform the painful movement when a concurrent reward is presented together with it. In other words, these results suggest that a concurrent reward diminished the effects of pain on response latencies, which is considered a proxy for avoidance tendency.

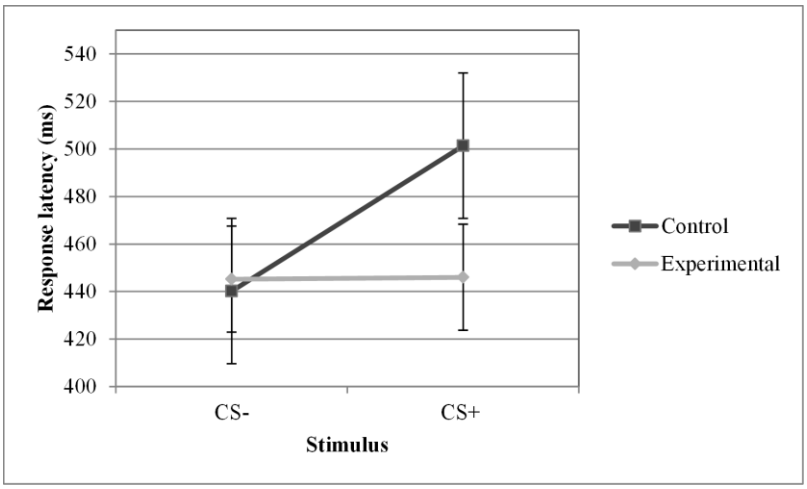

Figure I.1.3. Mean response latencies for CS+ and CS- movements for both experimental conditions (control/experimental).

Decision making behavior

A one-way ANOVA analysis with Condition (Control/Experimental) as within-subjects factor was run on the number of painful (CS+) movements participants performed in both conditions, yielding a significant main effect of Condition (Control/Experimental): $F(1,49) = 30.183$, $p < .001$, $d = -0.78$ [95% CI: -1.09, .-0.46], indicating that participants overall chose to perform the painful movement more often when a concurrent reward was presented (experimental condition), compared to

the absence of the reward (control condition). More specifically, 56 % of participants chose to avoid the painful movement completely in the control condition, whereas in the experimental condition only 20% of the participants always chose the safe movement. Only 4% of the participants performed all four painful movements in the control condition, whereas in the experimental condition 28% of the participants perform all painful movements. Figure I.1.4 displays the number of participants choosing to perform the 'painful' CS+ movement, either 0, 1, 2, 3, or 4 times in each condition.

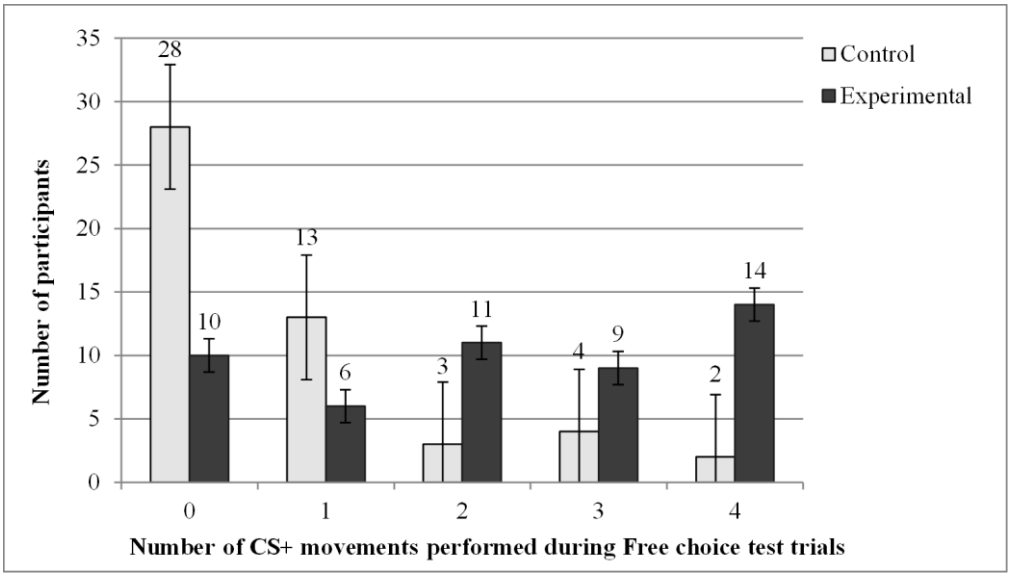

Figure I.1.4. CS+ Movements during choice trials. Number of participants choosing to perform the 'painful' CS+ movement for both the control and experimental conditions for each of the choice trials. Actual numbers are presented above each bar.

Additional Analyses

The correlations between the dependent variable (number of times performing the painful yet rewarding movement) and the predictors (importance of pain avoidance, importance of approach-reward, pain-related fear), as well as the intercorrelations between the predictors are presented in Table I.1.2 The pain-related fear score was the averaged pain-related fear score of the CS+ movements during the test phase in the experimental condition. Both the variables assessing the importance of the pain-avoidance goal as well as the approach-reward goal correlated significantly with the number of times participants performed the painful, yet rewarding movement (r = -.506; r = .549 respectively), whereas pain-related fear did not (r = -.058).

Backward regression analyses were conducted on the number of times participants chose to perform the painful movement when a concurrent reward was presented (see Table I.1.3). Pain-related fear, the importance of the goal to avoid pain, and the importance of the goal to win as much tickets as

possible were introduced into the initial model (see the section "Self-report measures"). The regression model with all three factors accounted for half of the variance, *adj.* R^2 = .513, F (2,46) = 18.17, p < .001. After removal of pain-related fear from the equation, the model still significantly explained half of the variance, *adj.* R^2 = *.501*, F (1,47) =25.65, p < .001. Both the pain-avoidance goal, β = -.260, t (47) = -4.65, p < .001, and the reward goal, β = .238, t (47) = 5.11, p < .001, significantly predicted participants' choice behavior.

Table I.1.2

Descriptives and correlations of the dependent and predictor variables of the regression analysis

	Variable	*M*	*SD*	2	3	4
1	Number of CS+ movements performed in Experimental condition	2.22	1.49	-.058	-.506[a]	.549[a]
2	Pain-related fear of CS+	6.37	1.66	1		
3	Pain avoidance goal	5.48	2.69	.06	1	
4	Reward goal	4.80	3.23	.212	-.069	1

[a] $p < .001$

Table I.1.3

Regression of number of painful movements performed during choice trials when a concurrent reward is present (experimental condition) on pain-related fear for the painful movement and self-reported goals

Model	Predictors	β	$t(\beta)$	R^2	*Adjusted* R^2	$F_{adj.\ R2}$	R^2_{change}	$F_{R2\ change}$
Model 1				.542	.513	18.172[a]	.539[a]	18.172[a]
	Pain-related fear of CS+	-.132	-1.437					
	Avoidance goal	-.254	-4.583[a]					
	Reward goal	.253	5.357[a]					
Model 2				.522	.501	25.645[a]	-.021	2.065
	Avoidance goal	-.260	-4.654[a]					
	Reward goal	.238	5.111[a]					

[a] $p < .001$

Discussion

The present study investigated whether introducing a concurrent reward along with a painful stimulus would result in a reduction of pain-related fear and less tendency to avoid using an adapted VJM paradigm. In the experimental condition a reward-US accompanied the pain-US, thus installing competing approach and avoidance tendencies, that is, avoiding the pain-US and approaching the reward-US. In the control condition, participants were informed that only one CS movement would be followed by a pain-US. On some trials during both conditions, participants were also instructed to choose and perform either the painful or the safe movement.

The results can be readily summarized. First, pain-expectancy was higher for painful movements than for safe movements in both conditions, indicating successful differential contingency learning. Second, participants were less hesitant to perform the painful movement when a concurrent reward was presented, compared to performing a painful movement alone. Third, and most importantly, during the choice trials, participants showed less frequent avoidant decision-making behavior when pain was accompanied by a reward than when pain was presented alone. Moreover, the regression analyses revealed that both pain-avoidance and approach-reward goals were significantly associated with avoidance behavior, whereas pain-related fear was not. More specifically, the more important it was for a participant to avoid pain, the less painful movements they performed, even though performing that movement also resulted in a reward. Similarly, the more important it was to earn tickets, the more participants performed the 'rewarding' movement, despite the presence of pain. Indeed, these results suggest that a concurrent reward may attenuate avoidance behavior. Fourth, there was no change in pain-related fear when performing a painful movement when a reward was presented compared to performing the painful movement without such reward. This finding is however in line with other studies showing that introducing a monetary incentive does not necessarily result in a decrease in pain-related fear (Leeuw, Goossens, et al., 2007; Van Damme et al., 2012).

The current study extends available evidence for the inclusion of a motivational perspective on avoidance tendencies and behavior, wherein the dynamics of several—possibly conflicting—goals should be considered. Avoidance behavior is considered a relatively stable response driven by a fear-based motivation to prevent further injury (Crombez et al., 2012; Hasenbring & Verbunt, 2010; Leeuw, Goossens, et al., 2007; Vlaeyen et al., 2009). However, the results of the current study show that avoidance can be influenced by the presence of concomitant, competing goals, such as the goal to earn a reward, even without changing pain-related fear itself (Karoly et al., 2008; Roy, 2010; Talmi et al., 2009; Van Damme et al., 2008, 2012). Thus, avoidance behavior may vary from situation-to-situation, and even within individuals.

Not only did this study investigate avoidance behavior directly by means of choice trials, employing the Voluntary Joystick Movement paradigm enabled us to also examine response latency as an index of avoidance tendencies. As found by Meulders et al. (2011), participants were slower

initiating the CS+ movement than the CS- movement in the control condition. When adding a monetary reward, this difference disappeared, suggesting that approaching a reward counteracted the avoidance tendency (Mir et al., 2011). Previous research has shown that using valuable incentives are capable of increasing pain tolerance (Cabanac, 1986), and that pain is able to increase motivation to work for a reward, if that reward is valuable enough (Gandhi et al., 2013). Current findings further demonstrate that a valuable incentive is capable of diminishing avoidance tendencies.

Interestingly, not all participants avoided the painful movement in the control condition. When looking at the choices more closely, participants often performed the painful movement just once. This might be due to the partial reinforcement rate of 50% for CS+ movements, which possibly induced exploratory behavior (Berlyne, 1960).

These results may have clinical implications and suggest that both pain-related and competing goals play a role in behavioral decision making and avoidance behavior. As such, this study provides experimental support for interventions that not focus solely on pain reduction goals, but also encourage daily life goals such as returning to work, engaging in sports or family activities. (Christiansen et al., 2010; Crombez et al., 2012; Schrooten & Vlaeyen, 2010; Van Damme et al., 2008; Vlaeyen et al., 2009). Examples of such interventions are cognitive-behavioral treatments (CBT) that incorporate both pain and normal life goals, often explore both advantages and disadvantages of goals, and strive for flexibility in the pursuit to be active despite pain (e.g., *Motivational Interviewing*; Ang et al., 2007; Jensen et al., 2003; Jones et al., 2004; and *Contextual CBT*; McCracken, MacKichan, & Eccleston, 2007; Schrooten, Vlaeyen et al., 2012; Vowles & McCracken, 2008) or treatments aimed at enhancing general functioning despite the experience of pain, while simultaneously helping patients to achieve valuable life goals (e.g., *graded activity, exposure in vivo*; Leeuw et al., 2008; Macedo, Smeets, Maher, Latimer, & McAuley, 2010; Schrooten, Vlaeyen, et al., 2012). However, it remains unclear for whom the incorporation of daily life goals results in the reduction of avoidance behavior, and which conditions contribute to recovered activity despite pain. Therefore these questions merit further scientific scrutiny.

There are some limitations that need further consideration. First, the sample size was relatively small (N = 55), resulting in relatively broad confidence intervals and a higher risk of type II errors, although power analyses indicated that the sample size was sufficient to obtain 93% power. Second, we tested our hypotheses in healthy undergraduate students. That is, the present results are preliminary and we do not claim that they pertain to a clinical population. In this experiment, participants had the choice between pain plus a reward or neither pain nor reward. For chronic pain patients however, the choice is not so clear-cut. Often they can only choose between 'the lesser of two evils': their usual level of pain or increased pain combined with a valued life goal (e.g., going out with friends). Thus, pain-related goals often compete with other daily life goals (Eccleston & Crombez, 1999; Van Damme et al., 2010; Wiech & Tracey, 2013) and are likely more salient in a clinical population. Therefore, future research would benefit from testing similar hypotheses in a clinical population, using an

adapted experimental design with higher ecological validity. Third, although previous research has shown that a financial reward is effective in increasing motivation, the ecological validity of a monetary incentive as a valued goal may be limited but is both easy and valuable for students in an experimental sample (Mir et al., 2011; Talmi et al., 2009; Van Damme et al., 2008; Vlaev, Seymour, Dolan, & Chater, 2009). Fourth, the use of some self-reported measures may have led to a confound among the measures (Van Poppel, de Vet, Koes, Smid, & Bouter, 2002), for example between the measures of pain-related fear and pain expectancy. We asked to indicate to what extent participants were afraid to receive a painful stimulus, which necessarily implies a measurement of pain expectancy. Given the difficulties disentangling pain-related fear and pain expectancy, this confound may explain the absence of a decrease in pain-related fear when presented with a concurrent reward. Furthermore, the self-report measure was only administered once, and did not take perceived harmfulness into account. Moreover, since fear is usually conceptualized as comprising of three relatively independent response systems, namely verbal responses (e.g., self-reports), behavioral responses (e.g., avoidance), and physiological responses (Lang, 1968), future research would benefit from including psychophysiological markers of pain-related fear (e.g., *eye blink startle*; Lang & McTeague, 2009) and pain (e.g., *RIII reflex*; Rhudy & France, 2007). Fifth, the importance of both the pain-avoidance goal and the approach-reward goal was assessed post-hoc. Future research should assess this prior to the experiment to avoid participants simply reporting according to what they did during the experiment.

In sum, this study provides experimental evidence that inclusion of a valuable competing goal such as obtaining a monetary reward, attenuates avoidance behavior. Therefore, there is some truth in Fordyce's law "*people don't hurt as much if they have something better to do*" (Fordyce, 1988). At the least, we were able to demonstrate that it has an effect upon avoidance tendencies and behavioral decision making; its putative effect upon the experience of pain awaits further scientific corroboration.

CHAPTER I.2

The impact of goal competition and goal prioritization on avoidance behavior and pain-related fear

Abstract

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

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Introduction

In Fear-Avoidance models, it is postulated that pain-related fear may lead to the development of chronic pain problems (Karoly & Ruehlman, 1995; Vlaeyen & Linton, 2000). Even though there is extensive evidence on the role of pain-related fear in the understanding and management of chronic pain problems (Leeuw, Houben, et al., 2007; Zale et al., 2013), some authors have argued that we need to increase the explanatory power of fear-avoidance models by taking into account a motivational perspective (Crombez et al., 2012; Van Damme et al., 2008; Vlaeyen & Linton, 2012; Vlaeyen et al., 2009). Patients with chronic pain not only aim to control pain and avoid bodily harm, but also often want to pursue other life goals as well (Christiansen et al., 2010; Crombez et al., 2012; Karoly et al., 2008; Karsdorp & Vlaeyen, 2011; Schrooten & Vlaeyen, 2010; Van Damme et al., 2008; Verhoeven et al., 2010; Vlaeyen & Linton, 2000; Wiech & Tracey, 2013). One of the consequences of pursuing multiple goals, is that the pursuit of one goal can facilitate and/or interfere with the pursuit of other goals (Boudreaux & Ozer, 2012). Being confronted with two competing goals, an individual has to make the—often difficult—choice which goal to pursue, whilst halting or even disengaging from the pursuit of the other goal (Boudreaux & Ozer, 2012; Eccles & Wigfield, 2002; Higgins, 1997; Higgins, 2002; Roy, 2010).

A motivational account may provide further insights into the processes identified by fear-avoidance models. Patients who consider their life goals as more important than pain avoidance, might be more inclined to expose themselves to painful events when these facilitate reaching these life goals. However, when patients prioritize the goal of avoiding pain at the expense of the attainment of other life goals, disability and increased suffering may be the result (Gandhi et al., 2013; Talmi et al., 2009). Only recently, research has begun to investigate the impact of competing goals on pain-related fear and avoidance behavior. Using the voluntary joystick movement (VJM) paradigm—which is a well-established human fear conditioning paradigm (Meulders et al., 2011; Meulders & Vlaeyen, 2012, 2013a)—Claes and colleagues found that a concurrent reward reduced avoidance behavior while pain-related fear remained unaltered (Claes, Karos, Meulders, Crombez, & Vlaeyen, 2014). However, this study did not investigate the role of individual differences in goal prioritization. It may very well be that the effects of goal competition differ as a function of which type of goal participants prefer, that is, preferring to avoid pain, or to earn a reward. Therefore, a replication and extension of this finding is warranted.

The current experiment was designed to further investigate the impact of goal competition on pain-related fear and avoidance behavior and to examine how goal preferences moderate these effects. To this end, we used the VJM paradigm (Claes et al., 2014), in which joystick movements serve as conditioned stimuli (CSs) and nociceptive electrocutaneous stimuli as unconditioned stimuli (USs). A reward—lottery tickets with which participants could win a self-selected prize—functioned as a competing goal. Furthermore, participants were a priori classified into three groups, depending on

which goal they considered most important: the pain-avoidance goal, the reward-seeking goal, or both goals valued as equally important. We expected that installing a competing goal would lead to decreases in pain-related fear, and less hesitation to perform the painful (CS+) movements, as well as making the choice to avoid pain less often. Moreover, we expected that goal prioritization would moderate these effects, with the strongest effects for participants preferring to obtain the reward, and the smallest effects for people preferring to avoid pain.

Differences between Study I.1 and Study I.2

In Study I.1, we studied the extent to which a concurrent reward altered self-reported pain-related fear, avoidance behavior—as measured by response latencies and decision making behavior. The experiment demonstrated that pain-related fear remained unaltered, whereas avoidance behavior decreased. However, the study had some limitations, which may have compromised the results. First, in study I.1, the pain-related fear measure was confounded by the pain expectancy measure, as we asked participants to indicate to what extent they were afraid of receiving a painful stimulus. Therefore, in Study I.2, we changed the wording of the pain-related fear measure to "to what extent were you afraid to perform this movement", and self-reported measures were completed retrospectively after a trial instead of before or a trial or at the end of a block. Second, the salience of the lottery prize was found to be limited for some participants. More specifically, *employed* participants considered the lottery prize of € 50 to be of little value. Note however that filtering out these participants did not yield different results. Nevertheless, we decided to maximize the value of the reward in study I.2: Participants could select a lottery prize worth approximately € 100 out of a list of possible prizes. Third, decision making behavior was only measured on four trials in both conditions, and were always administered after each block in study I.1. To increase power, we increased the number of choice trials to 12 in study I.2, and divided both experimental conditions in three separate phases: an acquisition phase, a test phase—in which participants performed signaled movements—, and a choice phase in which they chose to perform either the safe or the painful movement. Fourth, in study I.2 participants performed a movement as soon as a fixation cross appeared, instead of when it disappeared, ruling out possible effects of preparation (Mir et al., 2011). Lastly, in study I.1, goal importance was assessed post-hoc, which may have been influenced by the participants' behavior during the experiment. In study I.2, participants assessed goal importance and goal preference prior to the experimental condition.

These adjustments to the experimental design allowed us to address the same research questions as in Study I.1, that is, investigating self-reported pain-related fear and avoidance behavior as measured by choice behavior and response latencies. Additionally, study I.2 investigated to what extent a priori goal prioritization affects pain-related fear and avoidance behavior using between-group comparisons.

Methods

Participants

Participants were recruited by means of flyers and online advertisements. Sixty-five healthy individuals (28 male; M_{age} = 22.51 years, SD_{age} = 2.13) participated, for which they received € 12. Exclusion criteria were insufficient knowledge of the Dutch language, cardiovascular diseases, lung diseases, neurological diseases, other serious medical conditions, a current diagnosis of psychiatric disorders, chronic or acute pain, being asked to avoid stressful situations by a general practitioner, presence of electronic medical devices (e.g., pace-maker), anxiolytics or antidepressants, pregnancy, and deteriorated vision that is not corrected. All participants gave informed consent. The experimenter (female) informed participants that participation was voluntary and could be discontinued at any time and for any reason, without negative consequences. Ethical approval was obtained through the Ethics Committee of the Faculty of Psychology and Educational Sciences of the KU Leuven (Belgium). Three participants did not adhere to the experimental instructions. Five other participants indicated that both earning tickets and pain-avoidance were *un*important. These eight participants were excluded from further statistical analyses, as we reasoned that the experimental manipulation failed. The final sample consisted of 57 participants (21 male; M_{age} = 22.26 years, SD = 1.64). Based on the self-reported identification of the most important goal, participants were classified into three groups: *pain-avoidance* (N = 19; M_{age} = 22.1, SD_{age} = 1.6; 4 males), *reward-seeking* (N = 21; M_{age} = 22.9, SD_{age} = 2; 11 males), and *equally important* (N = 17; M_{age} = 22.3, SD_{age} = 2; 9 males).

Design summary

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

Apparatus and stimuli

Software

The experiment was run on a Windows XP computer (Dell OptiPlex 755; Dell, Round Rock, TX) with 2 GB random-access memory (RAM) and an Intel Core2 Duo processor (Intel, Santa Clara, CA) at 2.33 GHz and an ATI Radeon 2400 graphics card (Advanced Micro Devices, Sunnyvale, CA) with 256 MB of video RAM. The experiment was programmed in Affect, version 4.0 (Hermans, Clarysse, Baeyens, & Spruyt, 2005; Spruyt et al., 2010).

Stimulus material

We employed an adapted version of the VJM Paradigm (Claes et al., 2014; Meulders et al., 2011). Movements in four different directions served as conditioned stimuli (CS; either to the left,

right, upward, and downward). Participants carried out these movements with their dominant hand, using a Paccus Hawk Joystick (Paccus Interfaces BV, Almere, the Netherlands). Rectangular targets on the computer screen indicated the possible movement directions. There were two types of movement trials: (1) signaled trials, in which a change in the color of the target from black to purple indicated the to-be-performed movement, (2) choice trials: in which the participant chose and performed either one of both movements. These two trial types are depicted in Figure I.2.1.

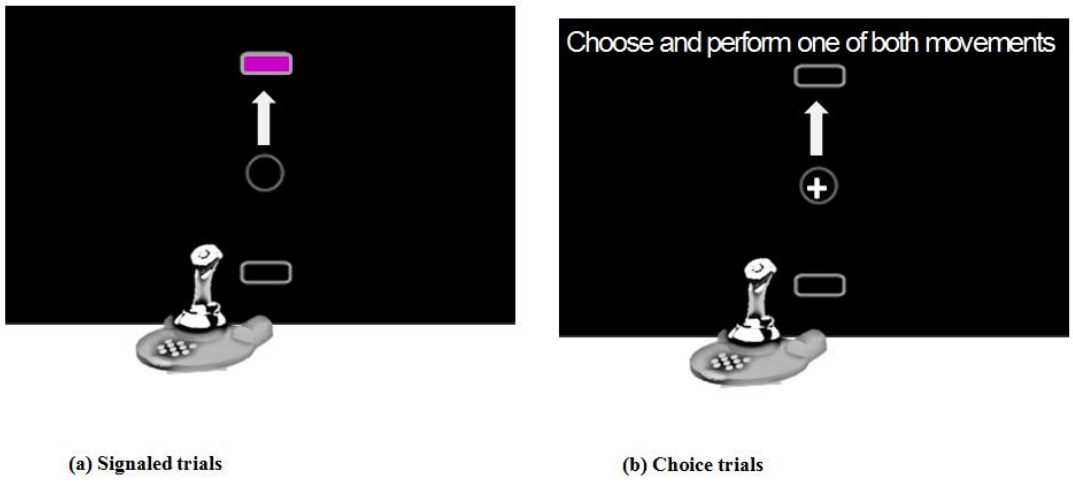

Figure I.2.1. Types of trials. (a) Signaled trials: to-be-performed movements are signaled by the purple coloring of the target; (b) Choice trials: the participant chooses and performs one of both movements.

A painful electrocutaneous stimulus consisting of trains of 20 ms sinusoid pulses with a frequency of 50 Hz, delivered for 1000 ms served as aversive unconditioned stimuli (pain-US). It was delivered by an Isolated Bipolar Current Stimulator (DS5; Digitimer ltd, Welwyn Garden City, England) through surface SensorMedics electrodes (1 cm diameter; SensorMedics Corp, San Diego, CA) filled with K-Y gel (Johnson & Johnson, New Brunswick, NJ) that were attached to the wrist of the dominant hand. Stimulus intensity was individually determined during a standard calibration procedure (see section *Stimulus calibration phase*; Meulders et al., 2011; Meulders & Vlaeyen, 2013b). In the experimental condition, lottery tickets served as positive unconditioned stimuli (reward-US). These lottery tickets represented the chance to win a prize worth approximately € 100, chosen by the participant during an individual prize selection procedure (see section *Experimental condition*). One reward-US represented two lottery tickets. Upon movement completion, participants received the pain-US with or without concurrent reward-US for reinforced, painful movements (CS+), but not for safe movements (CS-).

Self-reported Measures

Goal measures

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

Outcome measures

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

Manipulation check

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

Questionnaires

Participants completed several questionnaires after the experiment via an online system. Information about participants' age, sex, status, education, and work was collected. Furthermore, participants completed the Dutch versions of the Fear of Pain Questionnaire (FPQ-III-NL; Van Wijk & Hoogstraten, 2006), the Pain Catastrophizing Scale (PCS; Van Damme et al., 2002), and the Trait Positive Affectivity and Negative Affectivity Scale (PANAS; Engelen et al., 2006). These questionnaires were collected for descriptive purposes only, and data from these questionnaires were not included in any of the statistical analyses.

Response latency

Response latency was the time (in seconds) that participants needed to initiate the movement, more specifically, the time between the presentation of the starting signal (a fixation cross) and leaving the start region (a small circle in the middle of the computer screen; Chen & Bargh, 1999; Claes et al., 2014; Mineka & Gino, 1980).

Behavioral decisions

During choice trials, participants chose which movement they wanted to perform: the CS+ or the CS- movement. Participants completed twelve choice trials per condition. For each choice trial, the decision was registered. The choice for a painful movement was coded as 1, the choice for a safe movement as 0. The sum of the number of times the participants chose to perform the painful (CS+) movement was calculated per participant per condition, yielding a number between 0 and 12. This sum served as a measurement index of avoidant decision making behavior, with higher values indicating fewer avoidant decisions (Claes et al., 2014).

Choice switches

The number of times that participants switched between the CS+ and CS- movements during the choice phase were also calculated per condition. Switching was coded as 1, not switching was coded as 0. The sum per condition, varying from 0-12, served as an index of behavioral persistence, with lower numbers indicating higher persistence (Hampton, Adolphs, Tyszka, & O'Doherty, 2007; Meyer, Schley, & Fantino, 2011; Schrooten, Wiech, & Vlaeyen, 2014).

Procedure

At the beginning, participants were informed that the objective was to study the effects of different types of distractors on motor movements and that painful electrocutaneous stimuli would be administered as part of the procedure. The experiment consisted of 5 phases and lasted about 90 minutes. The experimental design is presented in Table I.2.1.

Stimulus calibration phase

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

Practice Phase

In the subsequent practice phase, participants rehearsed performing joystick movements and familiarized themselves with the task. Participants were required to perform the joystick movements towards a target as fast and as accurately as possible, and as soon as the start signal (fixation cross, '+') appeared. Further instructions stated that the to-be-performed movement was either signaled by a purple coloring of a rectangular target, or, when indicated on screen, could be freely chosen by the participant. When a movement was successfully performed, the corresponding target turned yellow. Participants did not receive any pain- or reward-USs during this phase. Participants received immediate visual feedback during the movements. A cursor on the screen indicated the position of the joystick during the movement, and an error message was displayed when participants performed an incorrect movement. The experimenter monitored the participants' movements via a closed-circuit-TV-installation and provided tailored feedback via intercom if needed. Participants completed 2 blocks of 5 practice trials: the first block consisted of 4 signaled movements in the horizontal movement plane (2 left, 2 right), and one choice trial. In the second block, movements were conducted in the vertical movement plane (upward/downward). A trial consisted of a 1.5 s-presentation of the fixation cross, and performance of the CS movement, which varies in length, depending on participant's movement speed. Inter trial Intervals (ITI) were 8 s in duration. The trial timing of a signaled trial is depicted in Figure I.2.2.

Table I.2.1

Experimental design

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

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

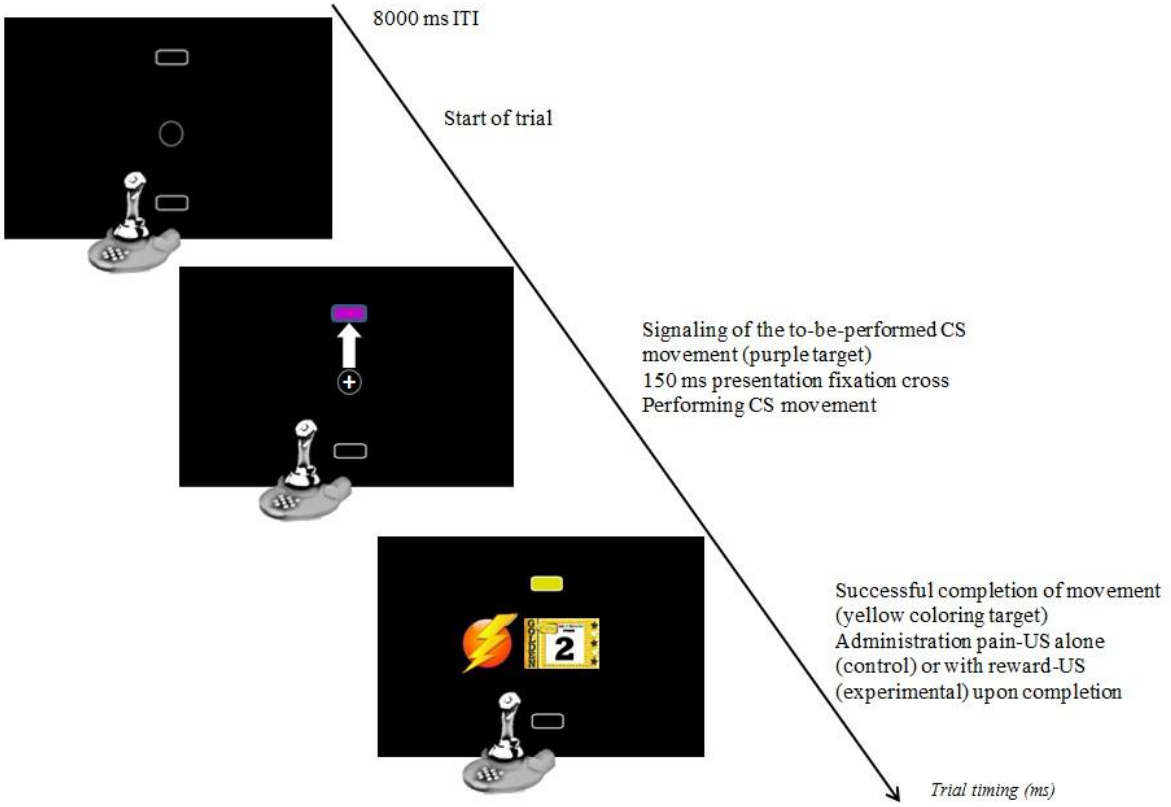

Figure I.2.2. Trial timing. The trial timing is depicted for a signaled trial. Trial timing is fairly similar for a choice trial, with the difference that there is no purple coloring of the target, but an instruction to choose and perform one of both movements. Here, the vertical movement plane is depicted. Note that movement plane is counterbalanced between conditions and between participants. Fifty percent of the CS+ movements were followed by the pain-US alone in the control condition, and by both the pain-US and reward-US in the experimental condition. The CS- movement was never reinforced. An arrow indicates the performed CS movement.

Experimental Phase

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

Control condition. The experimenter informed the participants that an electrocutaneous stimulus of varying intensity but maximally the selected stimulus (pain-US) would follow one movement (CS+), but not the other movement (CS-). In reality, the pain-US was always the same intensity, that is, the selected maximal intensity. Participants then completed an *acquisition* phase, consisting of 3 blocks of 8 trials (4 CS+, 4 CS-). Which movement served as a CS+ was counterbalanced between participants. Half of the CS+ trials were reinforced, that is, followed by the pain-US, whereas the CS- was never reinforced. USs were always administered immediately after

successful completion of a movement (i.e., after the target turned yellow). In every acquisition block, participants rated pain-related fear and pain-expectancy of 1 CS+ and 1 CS- movement. For the CS+ trial, pain intensity, and pain unpleasantness were also rated. Immediately following the acquisition phase, a test phase (one block of 12 CS+ and 12 CS- trials) took place testing our hypotheses. Again, reinforcement rate was 50%. Participants rated pain-related fear and pain-expectancy, and if applicable pain intensity and unpleasantness for 3 CS+ and 3 CS- movements. In the subsequent *choice phase*, participants were informed via instructions on the computer screen that they could choose which movement, either the CS+ or the CS-, they performed. The instructions emphasized that the same movement (CS+) would be followed by the pain-US, whereas the other movement (CS-) would not. In total, 4 blocks of 3 choice trials (12 movements in total) were completed. CS+ movements in the choice phase were 100% reinforced. Trial timing was identical to the practice phase.

Experimental Condition. The experimental condition was highly similar to the control condition, except for the following: (1) prior to the experimental condition, participants were informed that they could earn lottery tickets to win an additional prize of their choice. Participants then selected one out of a list of possible prizes; (2) participants were informed that one movement (CS+) would be followed by an electrocutaneous stimulus of varying intensity, but maximally the previously selected stimulus (pain-US) and lottery tickets (reward-US), whereas the other movement (CS-) would not. Instructions stressed that with these lottery tickets, participants could win the prize of their choice and the more tickets they earned, the higher the probability of winning the prize. Half of the CS+ trials were followed by both the pain-US and the reward-US in the acquisition and test phase, whereas in the choice phase all CS+ trials were reinforced; the pain-US and reward-US were presented simultaneously; (3) before the start of the acquisition phase, participants selected the goal they preferred; and (4) participants also rated ticket expectancy during the task.

Debriefing

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

Results

Data reduction and analysis

Response latencies < 250 ms and > 3000 ms were considered outliers and were therefore eliminated. Similarly, response latencies deviating more than 3 SDs from the within-subject mean calculated for the corresponding movement (CS+/CS-) and condition (control/experimental) were excluded from further analysis. 2 × 2 (Condition [control/experimental] × CS type [CS+/CS-]) Repeated Measures ANOVAs with Group (pain-avoidance/equally important/reward-seeking) as between-subjects variables were run for the self-reported measures and response latencies. For decision making behavior and choice switches, ANOVAs with Condition as the within-subject variable and Group as the between-subjects variable were performed. Follow-up planned contrasts were calculated when appropriate. All statistical analysis were run with SPSS 22.0 (IBM Corp, 2013). Greenhouse Geisser corrections were reported when appropriate. Effect sizes were calculated using general eta squared (η_G^2), with values of .02, .13, and .26 respectively indicating a small, medium, and large effect (Bakeman, 2005; Lakens, 2013; Olejnik & Algina, 2003).

Descriptive statistics

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

Self-reported measures (see Table I.2.2)

Manipulation check

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

Table I.2.2

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

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

Outcome measures

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

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

Response latencies

For response latency, a significant main effect of CS type emerged, $F(1,54) = 6.43$, $p = .014$, $\eta_G^2 = .005$, and this effect did not interact significantly with Condition nor with Group, $F(2,54) = 1.19$, $p = .281$, $\eta_G^2 < .001$; $F < 1$, respectively, indicating that participants were slower in initiating the CS+ movement compared to the CS- movement, irrespective of group or condition. Mean scores per condition and group of the self-reported measures and response latencies are presented in Table I.2.2.

Behavioral decisions

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

movements than the participants who preferred to obtain the reward (Reward Group), $t(19.54) = 2.386$, $p = .027$. The number of painful movements performed during the choice phase per Condition and Group is presented in Figure I.2.3.

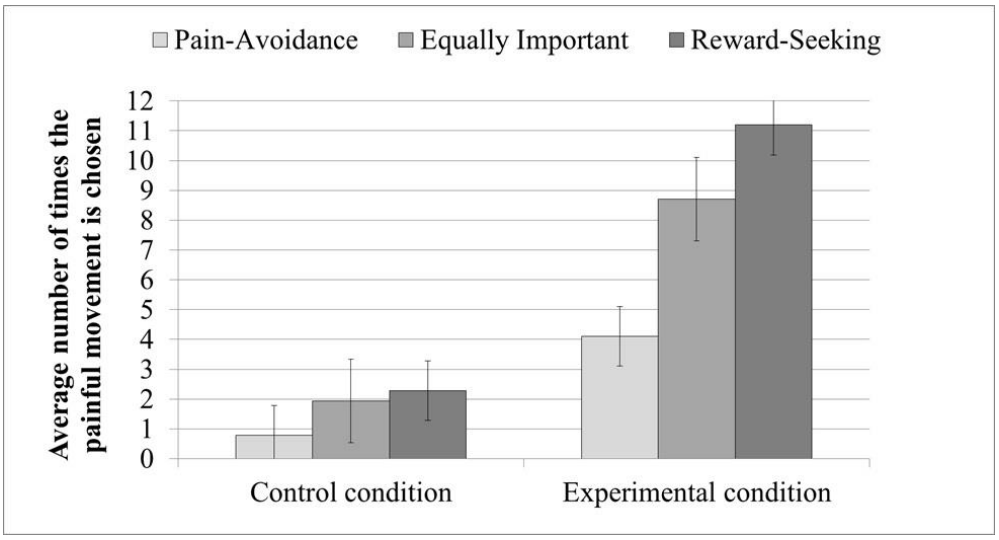

Figure I.2.3. Average number of painful movements performed during the choice phase.

Choice switches

For choice switches, neither the main effects of Condition nor Group were significant, $F < 1$. The Condition × Group interaction however, was significant, $F(2,54) = 7.51$, $p = .001$, $\eta_G^2 = .12$. Further analyses revealed that the participants who indicated that they preferred pain-avoidance, persisted in avoidance when there was no reward, but they were more flexible when the reward was presented, $t(18) = 2.557$, $p = .02$. The reward-seeking group however, were persistent in selecting the painful movement when accompanied by the reward, but switched more often between the painful and the safe movements when there was no reward, $t(20) = -2.726$, $p = .013$. The equally important group was equally flexible in both conditions, $t(16) = .079$, $p = .938$. The number of choice switches between painful and safe movements during the choice phase per Condition and Group is presented in Figure I.2.4.

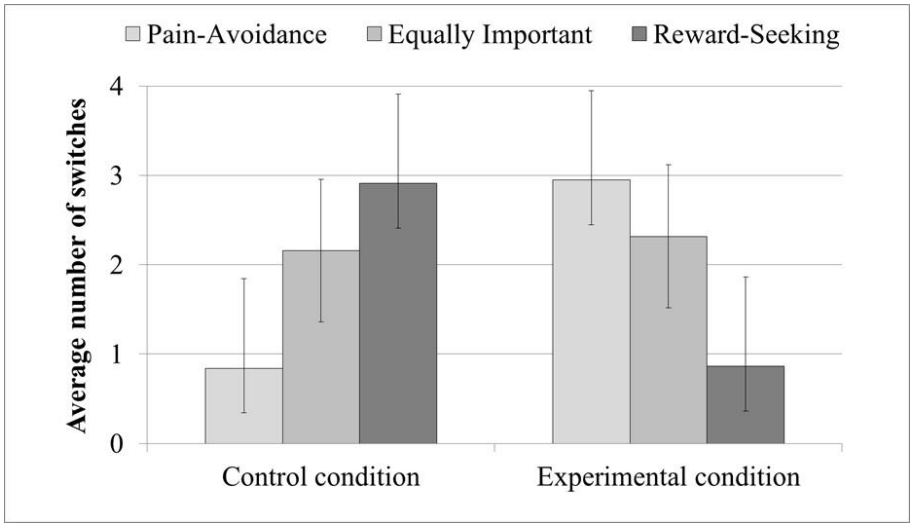

Figure I.2.4. Average number of choice switches during the Choice phase

Discussion

This study investigated whether a competing reward-seeking goal resulted in diminution of pain–related fear and avoidance behavior. Additionally, we investigated whether goal prioritization moderated this effect. For this purpose, we used the VJM paradigm (Claes et al., 2014; Meulders et al., 2011). In the control condition, participants performed movements in two different directions. One movement was accompanied by a painful stimulus, whereas the other was not. In the experimental condition, performing a painful movement also resulted in earning lottery tickets, thus creating a competition between pain-avoidance and reward-seeking tendencies.

The results can be summarized as follows. First, participants readily learned to differentiate the painful and safe movements, and which movement co-occurred with the reward. Second, participants who indicated a preference for the reward reported less pain-related fear. However, pain-related fear was unaffected by a reward during the painful movement, as was the case in our previous study (Claes et al., 2014). Third, participants were more hesitant performing a painful movement than a safe movement, irrespective of their preferred goal, and irrespective of the presence of the concurrent reward. Fourth, participants performed more painful movements when a concurrent reward was present than when it was absent. Moreover, the number of painful movements performed was affected by participants' preferred goal. More specifically, participants who indicated that they preferred to avoid pain, performed fewer painful movements than participants finding both goals equally important, who in turn performed fewer painful movements than did participants who indicated they were eager to earn the reward. Fifth, goal preference influenced the number of times that participants switched between performing a painful and a safe movement, or vice versa, which is indicative of behavioral persistence (Hampton et al., 2007; Meyer et al., 2011). It seems that when participants

preferred to avoid pain, they were rather persistent when nothing could be gained by the painful movement, whereas they switched more often when a concurrent reward was present. Conversely, participants who preferred the reward persisted in selecting the painful movement when accompanied with the reward-US, but at times avoided the painful movement when there was no reward.

Overall, the results of this study corroborate the view that avoidance behavior is a dynamic response that is not only influenced by pain and associated responding, but also by contextual factors and competing goals such as obtaining a reward (Eccleston & Crombez, 1999; Van Damme et al., 2012). As such, avoidance behavior may vary within individuals depending on the situation. Furthermore, this study further demonstrates that although self-reported pain-related fear remains unaltered, pursuing a competing goal may result in a diminution of observable avoidance behavior (Karoly et al., 2008; Talmi et al., 2009; Van Damme et al., 2012). Moreover, goal preference seems to moderate this effect. This finding is in line with the idea that pursuing one goal, that is, performing movements to earn tickets, may inhibit conflicting goals, that is, avoiding the same movement to deter a painful stimulation (Förster, Liberman, & Friedman, 2007; Riediger & Freund, 2004). Current Fear-Avoidance models, however, have difficulties explaining such findings, and would therefore benefit from including theories on behavioral decision making and goal pursuit (Crombez et al., 2012; Van Damme et al., 2012). More specifically, more insight is needed into the mechanisms underlying the incorporation of competing goals and their influence on avoidance behavior. One interesting avenue to explore is the impact of differences in value of the different goals and the expected outcome (i.e., the probability of successful goal attainment) on pain-related fear and avoidance behavior (Eccles & Wigfield, 2002; Higgins, 2002; Van Damme et al., 2012).

Our findings may have implications for clinical practice. First, the assessment of goals and goal importance might help us identify the person's valued life goals that compete with the goal to avoid pain. Identifying the situations in which individuals experience goal conflict or prioritize pain avoidance over other life goals may shed more light on the reasons why they are prone to engage in avoidance behavior. Although identification of goal prioritization has been clinically advocated, research on the presence of goal conflicts in patient populations and the underlying mechanisms is still lacking. Our study is one of the first to suggest that prioritizing nonpain goals over pain-avoidance goals might instigate individuals with chronic pain to expose themselves to daily activities, even though they are painful, whereas prioritizing pain-avoidance instigates avoidance behavior. Second, the current study provides evidence that avoidance behavior is the result not of only pain-related characteristics but also of contextual features such as pain-avoidance goals and reward-seeking goals. Indeed, the results of this study seem to corroborate that incorporating both pain-related and other, valuable life goals in treatment may be a more effective method to optimize treatment outcome, instead of focusing on pain-related fear alone (Christiansen et al., 2010; Crombez et al., 2012; Schrooten, Vlaeyen, et al., 2012). Third, the results indicated that pain avoidance could be overcome

by introducing a competitive valuable reward, even when participants considered pain avoidance as their most important goal. Thus, the current experiment provides further experimental evidence for interventions that bolster the importance of patients' relevant life goals, so that patients may leave the path of avoidance, and venture to be active despite pain (Gebhardt, 2006; Schrooten, Vlaeyen, et al., 2012; Van Damme et al., 2012). Examples of such already existing interventions are motivational interviewing, (contextual) cognitive-behavioral treatments, graded activity, and exposure in vivo (Jensen et al., 2003; Jones et al., 2004; McCracken et al., 2007; Schrooten, Vlaeyen, et al., 2012; Vowles & McCracken, 2008).

There are some limitations to consider. First, the sample used in this experiment included mostly healthy, undergraduate students, thus restricting generalizability to general and patient samples. In a related vein, we operationalized goal competition by introducing a concurrent reward when painful movements are performed. Although the use of monetary incentives has been effective in installing a reward-seeking goal previously in experimental settings (Talmi et al., 2009; Verhoeven et al., 2010; Vlaev et al., 2009), the ecological validity of using such a manipulation in a clinical sample is probably limited. Third, the grouping of participants was based upon self-reported preferences, and was not experimentally manipulated. One should therefore be careful with making causal inferences. Fourth, the current study only made use of self-reports and behavioral measures to investigate the hypotheses. To further corroborate these findings, future studies may include psychophysiological measures as well, such as the eye blink startle reflex (Lang & McTeague, 2009; Meulders et al., 2011) and pupil dilatation (Anderson & Yantis, 2012; Lang & Bradley, 2010). Fifth, we did not replicate the finding of Claes et al. (2014) that participants respond equally fast to the CS+ than to the CS- movement when a reward is presented. A difference in the operationalization of response latency no longer enabled participants in the current study to prepare and assess the situation before actually having to perform the movement, which may account for the difference in responding towards the painful and safe movement (Susan Mineka & Gino, 1980; Mir et al., 2011). Lastly, our hypotheses were tested in a test phase in which both goals were kept active by using intermittent reinforcement. It would be interesting to investigate what the effects of competing goals and goal prioritization on pain-related fear and avoidance behavior are in an extinction context. Such situations might reveal whether participants persist in their behavior when there is no further reinforcement. Despite these limitations, the results of the present study seem to indicate that including a reward diminishes avoidant decision making behavior, leaving pain-related fear unchanged. Moreover, goal preferences appear to moderate these effects.

PART II:

The effect of various types of goal conflicts on pain-related fear and avoidance behavior

CHAPTER II.1

An experimental investigation of the differential effects of various types of goal competition on defensive responding

Abstract

Successful adjustment to dynamic environments requires the simultaneous pursuit of multiple goals. However, the pursuit of multiple goals may bring about goal conflict. Despite evidence indicating that goal conflict can have a detrimental effect on subjective well-being, little is known about the effects of goal competition in the context of pain. This experiment investigated whether different types of goal competition increase pain-related fear and slow down pain-related decision-making. Forty-six participants completed a cross-directional movement task in which they learned to associate movements in one direction (e.g., left) with pain, and movements in the opposite direction (e.g., right) with safety; and that movements in other directions (e.g., up and down) were associated with reward and loss of reward, respectively. In the test phase, both phases were combined, creating different types of goal competition. The results showed that participants were most afraid of movements associated with two concurrent avoidance goals, and the least afraid of movements associated with approach-approach competition. Additionally, participants were slower in making a choice when presented with an avoidance-avoidance competition compared to approach-approach and avoidance-approach competition. These findings suggest that avoidance-avoidance competition increases fear and slows down decision-making compared to other types of competition.

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Introduction

Pain-related fear and avoidance behavior are considered key factors in the development and maintenance of chronic pain problems (Gheldof et al., 2010; Jensen et al., 2010; Leeuw, Goossens, et al., 2007; Turk & Wilson, 2010). However, there are unresolved issues that merit further scientific scrutiny. One of the concerns is that these defensive responses may vary within and across individuals and situations, dependent on the motivational context in which pain takes place in (Crombez et al., 2012; Schrooten & Vlaeyen, 2010; Van Damme et al., 2008; Vlaeyen et al., 2009; Wiech & Tracey, 2013). When experiencing pain, the goal to avoid (further) harm is often activated within a context of multiple competing goals, such as maintaining a relationship or engaging in regular exercise. There may, however, be an incompatibility or competition between these goals, which may bring about goal conflicts (Boudreaux & Ozer, 2012; Riediger & Freund, 2004). Goal competition arises when there is competition between two incompatible forces or responses of equal value, such as approach and avoidance tendencies. For example, it has been suggested that individuals experiencing chronic pain often pit the costs and benefits of pain avoidance against those of other activities, usually resulting in the prioritization of avoiding pain at the expense of other life goals (Gandhi et al., 2013; Roy, 2010; Talmi et al., 2009). Furthermore, different types of *goal competition* can be distinguished, on the basis of the valence of the *outcome* (Diederich, 2003; Gray, 1975)*:* (a) competition between tendencies to approach different desirable outcomes or goals, termed approach-approach competition; (b) Avoidance-avoidance competition, that is, being hemmed in by negative outcomes, all instilling avoidance tendencies; and (c) Approach-avoidance competition, which occurs when an event is associated with both negative and positive outcomes, and thus instills both approach and avoidance tendencies (Epstein, 1978; Lewin, 1935; Miller, 1944; Murray, 1975). Note that from this point of view, the absence of a positive stimulus is functionally equivalent to the presence of an aversive stimulus, and vice versa (McNaughton & Corr, 2004). Research in humans demonstrated that avoidance-avoidance conflicts are more difficult and thus take longer to solve than approach-approach competition, whereas approach-avoidance competition is situated somewhere in between (Barker, 1942; Brown, 1942; Diederich, 2003; Hovland & Sears, 1938; Lewin, 1935; Luce, Bettman, & Payne, 1997; Miller, 1944; Murray, 1975; Sears & Hovland, 1941). Preliminary cross-sectional evidence suggesting that goal conflicts are associated with pain-related fear (Karoly et al., 2008), greater reported pain intensity (Hardy et al., 2011), and negative affect (Emmons, 1986; Emmons & King, 1988; Goossens et al., 2010). Experimental research has shown that introducing a concurrent reward reduced avoidance behavior, although pain-related fear remained unaltered, whereas this effect was moderated by the importance of both pain-avoidance and reward-seeking (Claes, Crombez, & Vlaeyen, 2015; Claes et al., 2014). Furthermore, Schrooten et al. (2014) investigated the relations between pain-related choice behavior and pain perception when presented with different goal conflicts and showed that during avoidance-avoidance conflicts, more choice switching was associated with

higher fear levels. However, more research is needed scrutinizing the effects of different types of goal competition on pain-related fear and pain-related decision-making. Building on previous experimental studies (Claes, Crombez, & Vlaeyen, 2015; Claes et al., 2014), the current experiment investigated the impact of different types of goal competition in a context of pain by using a cross-directional joystick movement task (Meulders et al., 2011; Meulders & Vlaeyen, 2013a, 2013b). Participants performed joystick movements in two acquisition phases in counterbalanced order, each creating different movement-outcome associations. In the pain acquisition phase, movements were associated with a painful stimulus or safety. In the reward acquisition phase, movements were followed by the gain or loss of reward, comprised of lottery tickets. In subsequent phases, movements predicted either one or two of the outcomes, creating different types of goal competition. Based on existing literature indicating that avoidance-avoidance competition is harder to solve and evokes more conflict behavior than other types of competition (Lewin, 1935; Miller, 1944), we expected that avoidance-avoidance competition (pain and loss of reward) would lead to greater pain-related fear, longer choice latencies when choosing between two aversive outcomes, and less willingness to perform these movements compared to approach-approach competition (safety and reward). Approach-avoidance competition (pain and reward; safety and loss of reward) is expected to be associated with intermediate levels of pain-related fear and speed of decision-making.

Methods

Participants

Fifty-one healthy individuals (16 male, M_{age} = 22.25, SD_{age} = 2.73) completed the experiment, for which they either received credits to fulfil course requirements or 10 euros. Participants were recruited via the online recruitment system of the Faculty of Psychology and Educational Sciences of the KU Leuven and via flyers distributed across campus. There were seven health- and safety related exclusion criteria: 1) pregnancy, 2) current or history of cardiovascular diseases, 3) chronic or acute respiratory disease, e.g. asthma, 4) neurological diseases, e.g. epilepsy, 5) cardiac pacemaker or presence of any other electronic medical devices, 6) other severe medical conditions, and 7) being asked by the MD to avoid stressful situations. Six additional task-related exclusion criteria were formulated a priori as well: 1) insufficient understanding and knowledge of the Dutch language, 2) acute or chronic pain, or pain at the wrist/hand or related areas that interfere with performing joystick movements, 3) hearing problems, 4) problems with eyesight that are uncorrected by lenses or glasses, including color blindness, and 5) not successfully learning the contingencies during the pain and/or reward acquisition phase, defined as wrongly answering one of the contingency check questions at least 5 times in a row, and 6) reporting that both pain avoidance and earning tickets were unimportant, which may indicate that our experimental manipulation did not work.

All participants gave informed consent after receiving study information both orally and in writing. The current study was approved by the Ethical Committee of the Faculty of Psychology and Educational Sciences, KU Leuven, Belgium (registration number S56294). Four participants did not successfully learn the contingencies during the acquisition phase, and one participant indicated both goals were unimportant. Therefore, these participants were all excluded from further data-analysis. The remaining sample consisted of 46 participants (16 male), with a mean age of 22.24 years (*SD* = 2.71).

Apparatus and stimuli

Software

The experiment was programmed in Affect, version 4.0 (Hermans et al., 2005; Spruyt et al., 2010), and run on an Windows XP computer (Dell OptiPlex 755; Dell, Round Rock, TX) with 2 GB random-access memory (RAM), an Intel Core2 Duo processor (Intel, Santa Clara, CA) at 2.33 GHz, and an ATI Radeon 2400 graphics card (Advanced Micro Devices, Sunnyvale, CA) with 256 MB of video RAM.

Stimulus material

Participants completed a cross-directional joystick movement task (Meulders et al., 2011). A larger circle divided in eight equally large quadrants was visible on the middle of the computer screen. These quadrants served as discriminative stimuli (SD), each representing a different movement direction. A lit-up quadrant signalled the to-be-performed movement. A small circle presented in the middle of a large circle served as the start region. Participants carried out the movements with their dominant hand, using a Paccus Hawk Joystick (Paccus Interfaces BV, Almere, The Netherlands). Four different outcomes (Os) were employed. A first, aversive outcome was the administration of an individually selected painful electrocutaneous stimulus (O_{pain}) of 1000 ms, consisting of trains of 20-ms sinusoid pulses with a frequency of 50 Hz, delivered by an Isolated Bipolar current stimulator (DS5; Digitimer ltd, Welwyn Garden City, England) through surface SensorMedics electrodes (⌀ 1 cm; SensorMedics Corp, San Diego, CA) filled with KY gel (Johnson & Johnson, New Brunswick, NJ) attached to the wrist of the dominant hand. Movements could also be associated with a first positive outcome, that is, the absence of painful electrocutaneous stimulations (O_{safety}). The two remaining outcomes were winning 2 lottery tickets (O_{win}; positive) or losing 1 lottery ticket (O_{lose}; negative). With these lottery tickets, participants automatically entered a lottery to win a self-selected prize worth approximately € 100. Eventually in the test phase, each movement was associated with a different (combination of) outcome(s).

A small lottery ticket cue depicted on the top right of the screen indicated whether participants could win or lose tickets in the present phase of the experiment. Another cue, a thunderbolt, signalled whether participants could receive painful electrocutaneous stimuli.

Self-reported measures

Manipulation check

Immediately after the individual calibration of the painful electrocutaneous stimulation, participants were asked to rate how *painful*, how *unpleasant*, and how *tolerable* the selected painful electrocutaneous stimulus was, using an 11-point Likert-scale ranging from 0 (not at all) to 10 (very much). Pain intensity was also assessed in a qualitative manner, using the following indicators: mild, medium, serious, and enormous. Similarly, participants assessed how *valuable* and how *pleasant* they found the lottery tickets on an 11-point Likert scale ranging from 0 (not at all) to 10 (very much). During the pain acquisition phase, participants were asked to indicate which movements predicted the painful electrocutaneous stimulus, and which movements predicted safety by clicking the movements' SDs using a computer mouse. Similarly, during the reward acquisition phase, they were asked to indicate which movement predicted winning lottery tickets and which ones predicted losing lottery tickets. The number of blocks needed per acquisition phase was recorded.

Manipulation check: goal measures

After individually determining the intensity of the painful electrocutaneous stimulus and content of the lottery prize, the goals participants were aiming at for the current experiment were assessed. Participants judged the *importance* of the goal to earn the reward (reward-seeking goal) and the goal to avoid pain (pain-avoidance goal), together with two distractor goals, namely the goal to successfully complete the experiment, and the goal to learn the associations, on an 11-point Likert scale ranging from 0 (not at all) to 10 (very much). They additionally indicated which goal was more important: the reward-seeking goal, the pain-avoidance goal, both goals equally important, or both goals equally unimportant.

Outcome measures

During the test phase, participants rated a priori how *afraid* and how *eager* they were to perform the movement on an 11-point Likert scale ranging from 0 (not at all) to 10 (very much). Participants assessed pain-related fear and eagerness once per movement in the pain acquisition phase, once per movement in the reward acquisition phase, and thrice per movement in the test phase. Similarly, during the test phase, participants indicated whether they were *willing* to perform the lit-up movement in a subsequent phase of the experiment (*willingness*) thrice per movement. A 'yes' was coded as 1, and a 'no' was coded as a 0.

During the test phase, Participants were presented with trials representing 4 different types of competition (see test phase). Participants selected which of the lit-up movements they would perform in a subsequent phase of the experiment (*choice behavior*). Possible movements to choose from were indicated by lighting up the correspondent movement's SD. The percentage of participants choosing for a specific movement was calculated over the total number of choice trials by all participants: 4 (competition types) × 3 (trials per type) × 46 (participants) = 552.

Questionnaires

Participants completed several questionnaires online after the experimental session solely for descriptive purposes. The questionnaires involved were the Trait Positive Affectivity and Negative Affectivity Scale (PANAS; Engelen et al., 2006), the trait version of the State-Trait Anxiety Inventory(STAI; Van der Ploeg, 1980), and the Self-Control Scale (SCS; Tangney, Baumeister, & Boone, 2004). Additionally, socio-demographical information was collected.

Behavioral measures

For each trial in which participants performed a movement, response latency and response duration were recorded (Meulders & Vlaeyen, 2012, 2013a). *Response latency* was defined as the time of movement-onset, and operationalized as the time from the presentation of the fixation cross (start signal, '+') until participants left the start region in the centre of the screen. *Response duration* was operationalized as the time from movement-onset until movement completion. During the test phase, on trials in which participants indicated their willingness to perform a movement, *decision latency* was measured and operationalized as the time from SD presentation to answering the question. Similarly, together with participant's choice behavior, the time needed to make a choice as to which of the lit-up movements to perform in a subsequent phase was recorded (choice latency). This *choice latency* was operationalized as the time from trial onset upon selecting one of the lit-up movements.

Procedure

The experimental task included 5 phases: a preparation phase, a practice phase, an acquisition phase (which consisted of both a pain and a reward acquisition phase), a test phase, and a debriefing. The experimental session lasted about 75 minutes. Figure II.1.1 provides an overview of the experimental design.

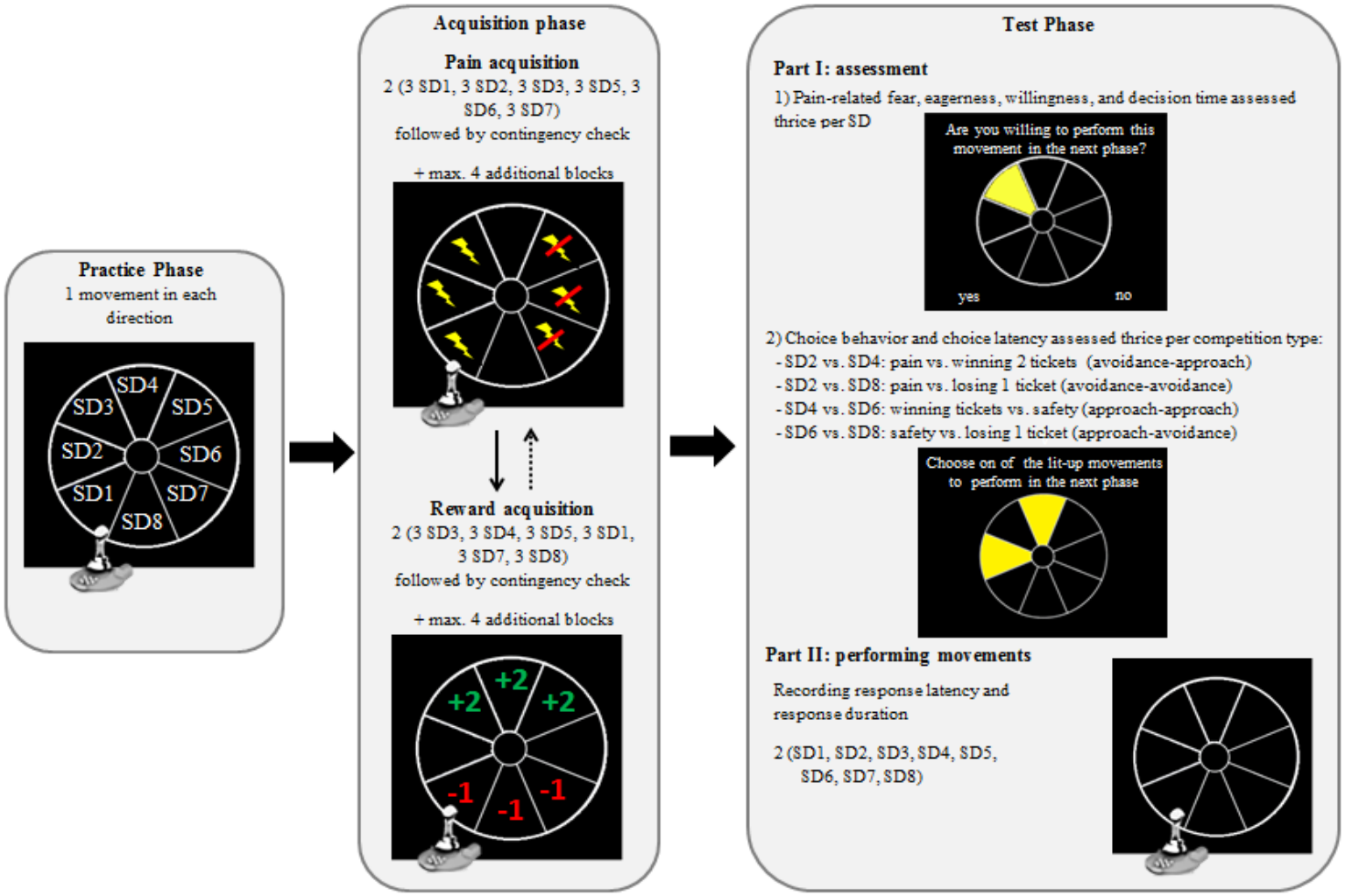

Figure II.1.1. Overview experimental design. 'SD' indicates a movement. A thunderbolt represents a painful electrocutaneous stimulus, whereas a crossed thunderbolt indicates safety. A '+2' indicates the earning of 2 lottery tickets, whereas a '-1' indicates losing 1 lottery ticket. The order in which the acquisition phases were run was counterbalanced between participants, as indicated by the arrows. A joystick indicates that movements were performed. The reinforcement rate in the acquisition phase was 67%. Movements were not reinforced during the test phase.

Preparation phase

Upon arrival, the experimenter informed participants about the course of the experimental session and asked participants to give informed consent. First, the level of stimulus intensity was individually determined during a calibration phase. Participants were instructed to select a painful stimulus that required some effort to tolerate. Painful electrocutaneous stimuli of increasing intensity were administered. After every stimulus, participants were asked to rate pain intensity, pain unpleasantness and pain tolerance. The experimenter stressed that participants themselves could indicate when they no longer wished to increase stimulus intensity, or when the stimulus intensity level needed to be set back to a lower level. The experimenter asked participants whether they agreed upon receiving painful stimuli of maximally the selected intensity during the experimental task. Next, the experimenter told participants that during the experiment, participants could earn lottery tickets, with which they could win a prize of their choice. Therefore, participants were asked to select one prize out of a list of possible prizes. Finally, before advancing to the experimental task, participants filled in questions regarding their goals for the experiment.

Practice phase

Participants first completed a practice phase to acquaint themselves with the experimental task and to practice the joystick movements. This phase comprised of 8 trials, one block of one movement in each movement direction. None of the outcomes were presented. The experimenter instructed the participants to move as quickly and accurately as possible and provided feedback via intercom when necessary. Participants had to position the joystick in the centre of the field, which was indicated by the purple coloring of the start region to start a new trial. A trial started with the presentation of the large circle divided in eight equal quadrants (SDs; see Figure II.1.1). After 10 ms, one of the SDs lit up, signalling the to-be-performed movement. A start signal (fixation cross) appeared 250 ms later, indicating that participants could now perform the movement. Movement completion was dependent on participants' movement speed. Inter Trial Intervals (ITI) were 5s in duration (see Figure II.1.2).

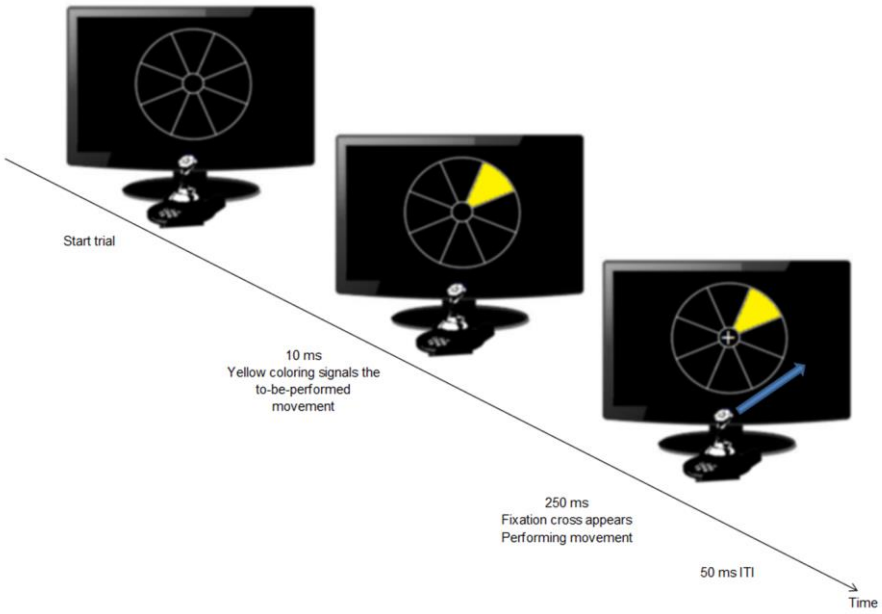

Figure II.1.2. Trial timing. In the acquisition phases, the outcomes are delivered during the movement, and continue when the movement is completed. ITI = inter trial interval.

Acquisition phase

Next, participants advanced to a pain acquisition and a reward acquisition phase, which were completed in counterbalanced order. The specific movement-outcome associations were also counterbalanced between participants.

Pain acquisition phase. Participants were informed that in this phase, they could receive painful electrocutaneous stimuli, as indicated by the thunderbolt cue on top of the screen. No tickets could be earned or lost during this phase. The experimenter instructed them to learn which movements were followed by the painful stimulus, and which movements were associated with safety. Participants completed 2 blocks of 3 movements in 6 different movement directions, either in the horizontal movement plane(3 left, 3 right) or the vertical movement plane (3 up, 3 down), dependent on the results of the counterbalancing procedure. All movements in one direction, e.g., left, were associated with the painful stimulus, whereas movements in the other direction were associated with safety. Reinforcement rate was 67%. A contingency check was administered to check whether participants successfully learned the associations; if not, a maximum of 4 additional acquisition blocks was added; if yes, participants rated their movement-related fear of pain and the eagerness to perform the movement once for each of the 6 different movements separately. Trial timing was similar as in the practice phase.

Reward acquisition phase. The reward acquisition phase was similar to the pain acquisition phase, but differed in the following ways: (1) participants were informed that in this phase, they could win or lose lottery tickets, as indicated by the ticket-cue on the top right of the screen; (2) participants were informed they received 10 lottery tickets to start with, and that the higher the number of tickets earned, the greater the chances of winning the lottery. Participants however received an equal number

of lottery tickets; (3) no painful electrocutaneous stimuli would be administered; and (4) the to-be-performed movements were conducted in the opposite movement plane than in the pain acquisition phase.

Test phase

After completing both acquisition phases, there was a test phase consisting of two parts. First, participants were informed that in the remainder of the experiment, they would be confronted with all movement SDs again, but that now they were associated with their respective outcomes. As such, movements could predict one or two different outcomes. For example, when a particular movement was accompanied with a painful electrocutaneous stimulus in the pain acquisition phase, and winning 2 lottery tickets in the reward acquisition phase, this movement would now be associated with both pain and lottery tickets. In the first part, participants were asked (1) to rate pain-related fear and eagerness for the lit-up movement; (2) to indicate whether they wanted to perform the lit-up movement in the subsequent phase. Willingness and decision latency were recorded; and (3) to choose which of the lit-up movements they would perform in the subsequent phase. We recorded their choice, as well as the choice latency. These three different trial types were presented once per block intermixed and in random order. For (1) and (2), only one of the movement SDs lit up, whereas for (3), multiple movements SDs lit up. These combinations of lit-up movements represented 4 different competition types: (a) avoidance-approach: pain vs. receiving lottery tickets, (b) approach-approach: safety vs. receiving lottery tickets, (c) avoidance-avoidance: pain vs. losing lottery tickets, and (d) approach-avoidance: safety vs. losing lottery tickets. The experimenter emphasized that participants would not receive any of the outcomes when answering the questions, but that they had to bear in mind they could receive the outcomes in the following part. In the second part of the test phase, participants performed two movements in each movement direction (16 trials). Although instructions informed participants that the movements would be accompanied with the outcomes they were associated with in the acquisition phase, none of the movements were reinforced.

Debriefing

Upon completion of the experimental session, participants were informed about the course of the lottery. They could be contacted through their preferred address if they won the selected prize. All participants received an equal number of lottery tickets and thus had an equal chance of winning the lottery. Lastly, they were debriefed about the true aim of the experiment and thanked for their participation. The lottery winner was selected at random by the computer.

Results

Data reduction and analysis

For the variables pain-related fear, eagerness, willingness, decision latency, response latency and response duration, we tested our hypotheses using movements associated with a combination of outcomes. For choice behavior and choice latency, 2 movements, which each predicted a different outcome, were presented. Per participant, there was one measurement available per movement per block for each of these variables, thus comprising data of 12 trials for all variables except response latency and response duration, which contain data on 8 trials per participant.

Competition(avoidance-avoidance[O_{pain}-O_{lose}]/approach-approach[O_{win}-O_{safety}]/approach-avoidance[O_{safety}-O_{lose}]/avoidance-approach[O_{pain}-O_{win}]) × Block Repeated Measures analysis of variance (ANOVAs) were carried out to test our hypotheses, and when appropriate, planned contrasts were calculated. We used SPSS 22.0 to conduct our analyses. Generalized eta squared (η_G^2) is reported as a measure of effect size (Bakeman, 2005; Lakens, 2013; Olejnik & Algina, 2003).

Descriptive statistics

The average intensity of the selected painful electrocutaneous stimulus was 10.9 mA (*SD* = 4.191). Mean self-reported pain intensity, pain unpleasantness, and pain tolerability score were 8.5 (*SD* = 0.753), 8.6 (*SD* = 0.777), and 8.3 *(SD*=0.929) respectively. Mean ticket value and ticket pleasantness ratings were 6.4 (*SD* = 2.473), and 7.7 (*SD* = 1.851) respectively. Mean importance of pain avoidance rating was 6.8 (*SD* = 1.977), whereas mean importance of earning tickets rating was 6.9 (*SD* = 2.219); the importance of pain avoidance and the importance of earning tickets did not significantly differ, $t(45) = -0.286$, $p = .776$. Mean PANAS scores were 35.6 (*SD* = 5.85) for the positive affect and 18.3 (*SD* = 5.45) for the negative affect scale. Mean total STAI and SCS scores were 36.6 (*SD* = 8.19), and 3.1 (*SD* = 0.47) respectively.

Self-reported measures

For *pain-related fear* Repeated Measures ANOVAs revealed a significant main effect of Competition, $F(3,43) = 246.23$, $p < .001$, $\eta_G^2 = .801$, whereas both the main effect of Block $F(2,43) = 1.73$, $p = .185$, $\eta_G^2 = .002$, and the Competition × Block interaction, $F(6,43) = 1.88$, $p = .129$, $\eta_G^2 = .007$, were non-significant. Planned contrasts indicate that the avoidance-avoidance (O_{pain}-O_{lose}) competition installed more pain-related fear than the avoidance-approach competition (O_{pain}-O_{win}), $F(1,45) = 6.45$, $p = .015$, $\eta_G^2 = .084$, which in turn elicited more fear than the approach-avoidance competition (O_{safety}-O_{lose}), $F(1,45) = 119.45$, $p < .001$, $\eta_G^2 = .701$. Participants were the least afraid of the approach-approach competition (O_{win}-O_{safety}), $F(1,45) = 60.6$, $p < .001$, $\eta_G^2 = .0392$. For *eagerness*, the analyses yielded a significant main effect of Competition, $F(3,43) = 173.64$ $p < .001$, $\eta_G^2 = .754$. The main

effect of Block was also significant, $F(2,43) = 3.94$, $p = .026$, $\eta_G^2 = .004$, as was the Competition × Block interaction, $F(6,43) = 3.6$, $p = .009$, $\eta_G^2 = .011$. This interaction mainly seems to be caused by a steeper decline from block 2 to block 3 in eagerness for approach-avoidance competition (safety – loss of reward) compared to the low, steady eagerness ratings for avoidance-avoidance competition (pain – loss of reward), $F(1,45) = 6.17$, $p = .017$, $\eta_G^2 = .0134$. Furthermore, planned contrasts indicate that participants were less eager to perform the movement associated with avoidance-avoidance (O_{pain}-O_{lose}) competition compared to the approach-avoidance competition (O_{safety}-O_{lose}), $F(1,45) = 32.67$, $p < .001$, $\eta_G^2 = .381$ .Participants were less eager to perform the approach-avoidance competition (O_{safety}-O_{lose}) than the avoidance-approach competition (O_{pain}-O_{win}), $F(1,45) = 8.35$, $p = .006$, $\eta_G^2 = .152$, while participants were the most eager to perform the movement associated with approach-approach competition (O_{safety}-O_{win}), $F(1,45) = 203.92$, $p < .001$, $\eta_G^2 = .805$. The results for pain-related fear and eagerness are depicted in Figure II.1.3.

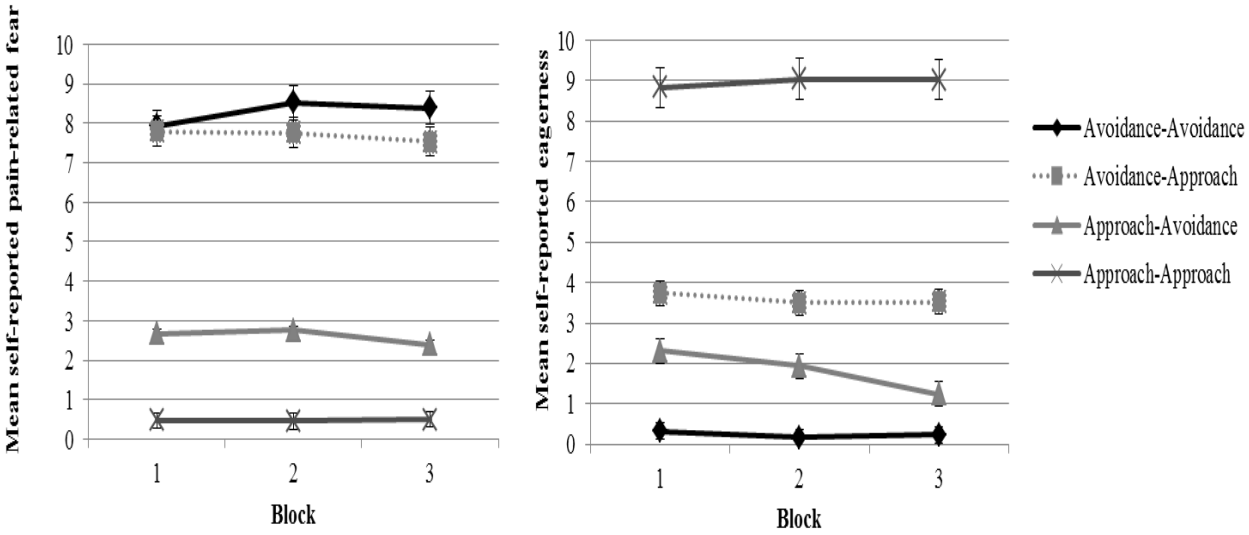

Figure II.1.3. Mean self-reported pain-related fear and eagerness.

For self-reported *willingness* to perform the movements, Repeated Measures ANOVAs yielded a significant main effect of Competition, $F(3,43) = 81.92$, $p < .001$, $\eta_G^2 = .597$. The main effect of Block, $F(2,43) = 2.46$, $p = .093$, $\eta_G^2 = .002$, nor the Competition × Block interaction was significant, $F < 1$. Table II.1.1 depicts the number and the percentage of participants willing to perform the depicted movement in a later phase per competition and per block. All participants (except one) were unwilling to perform the movement associated with pain and loss of reward (avoidance-avoidance); and all participants wished to perform the movement associated with safety and reward (approach-approach). When asked if they would be willing to perform movement associated with the painful outcome and reward outcome (avoidance-approach) 54 to 59% of participants indicated 'yes', whereas

only 21 to 31% of participants was willing to perform the movement associated with safety and losing lottery tickets (approach-avoidance).

The frequency and percentage of trials a movement(outcome) was selected during choice trials for all participants for each competition type are shown in Table II.1.2. For the avoidance-approach (O_{pain}-O_{win}), trials, all participants always selected the movement associated with winning lottery tickets. In the approach-avoidance (O_{safety}-O_{lose}) trials, participants chose the safe movement over the movement associated with losing lottery tickets in 97.8% of trials. In the approach-approach (O_{safety}-O_{win}) trials, the movement associated with winning lottery tickets was selected in 87.7% of trials, whereas the safe movement was selected in 12.3% of the trials. In the avoidance-avoidance (O_{pain}-O_{lose}), trials, participants chose the painful movement in 27.5% of trials, the movement associated with losing lottery tickets was chosen in the remaining 72.5%.

Behavioral measures

Repeated Measures ANOVAs carried out for *response latency* showed no main effect of Block, $F(2,43) = 1.898$, $p = .175$, $\eta_G^2 = .002$, no main effect of Competition, $F(3,43) = 1.82$, $p = .179$, $\eta_G^2 = .007$, and no Competition × Block interaction, $F(6,43) = 1.53$, $p = .225$, $\eta_G^2 = .013$. Similarly, the main effect of Block, $F(2,43) = 3.868$, $p = .055$, $\eta_G^2 = .013$, main effect of Competition, $F < 1$, and the interaction, $F < 1$, were non-significant for response duration.

Statistical analyses on *decision latency* revealed a significant main effect of Block, $F(2,43) = 26.286$, $p < .001$, $\eta_G^2 = .081$, indicating that participants became gradually faster in making their decision whether or not to perform the movement in a later phase. There was also a main effect of Competition, $F(3,43) = 14.76$, $p < .001$, $\eta_G^2 = .086$. The Competition × Block interaction however was not significant, $F(6,43) = 1.18$, $p = .321$, $\eta_G^2 = .014$ (see Figure II.1.4). Furthermore, analyses show that participants needed significantly more time to make a decision during the approach-avoidance (safety and loss of reward) vs. avoidance-approach (pain and reward) competition, $F(1,45) = 8.249$, $p = .006$, $\eta_G^2 = .121$.

However, the time needed to make a decision when presented with the avoidance-approach competition (pain and reward) tended to be slower than for the approach-approach (safety and reward) competition, $F(1,45) = 3.71$, $p = .06$, $\eta_G^2 = .06$. The approach-approach (safety and reward) competition in turn did not differ from the avoidance-avoidance competition, $F < 1$.

Table II.1.1

Overview of number (frequency) and percentage (%) of participants willing to perform the movement associated with the different types of goal competition per block.

Outcome 1	Outcome 2	Competition type	Block					
			1		2		3	
			Freq	*%*	*Freq*	*%*	*Freq*	*%*
Pain	Losing tickets	Avoidance-Avoidance	1	2.2	0	0,00	1	2.2
Pain	Winning tickets	Avoidance-Approach	27	58.7	26	56.5	25	54.3
Safety	Losing tickets	Approach-Avoidance	14	30.4	10	21.7	11	23.9
Safety	Winning tickets	Approach-Approach	46	100	46	100	46	100

Note. Frequency represents the number of participants per block willing to perform the movement in a later phase.Participants were enabled to choose only once per block per type of competition.

Table II.1.2

Choice behavior in number and percentage per choice per competition type

Competition type	Chosen movement	Block 1		Block 2		Block 3		Total	
		N	*%*	*N*	*%*	*N*	*%*	*N*	*%*
avoidance-avoidance	pain	11	23,9%	14	30,4%	13	28,3%	38	27,5%
	lose tickets	35	76,1%	32	69,6%	33	71,7%	100	72,5%
avoidance-approach	pain	0	0,0%	0	0,0%	0	0,0%	0	0,0%
	win tickets	46	100,0%	46	100,0%	46	100,0%	138	100,0%
approach-avoidance	safety	44	95,7%	45	97,8%	46	100,0%	135	97,8%
	lose tickets	2	4,3%	1	2,2%	0	0,0%	3	2,2%
approach-approach	safety	6	13,0%	5	10,9%	6	13,0%	17	12,3%
	win tickets	40	87,0%	41	89,1%	40	87,0%	121	87,7%

Repeated Measures ANOVAs for choice latency revealed a main effect of Block, indicating that participants over time decided faster which of both movements to perform, $F(2,43) = 19.63$, $p < .001$, $\eta_G^2 = .042$. There was also a significant main effect of Competition, $F(3,43) = 13.99$, $p < .001$, $\eta_G^2 = .131$. The interaction between these variables was nonsignificant, $F < 1$. Planned comparisons revealed that participants responded equally fast to the avoidance-approach (pain and reward) decision compared to the approach-avoidance decision (safety and loss of reward), $F(1,45) = 2.4$, $p = .128$, $\eta_G^2 = .005$. Participants also did not need more time comparing the latter with an approach-approach (safety and reward) decision, $F(1,45) = 1.962$, $p = .168$, $\eta_G^2 = .027$. It however took participants significantly longer to decide which movement to perform during the avoidance-avoidance (pain and loss of reward) competition compared to the approach-approach (safety and reward) competition, $F(1,45) = 11.32$, $p = 0.02$, $\eta_G^2 = 0.182$. The results for choice latency are depicted in Figure II.1.4.

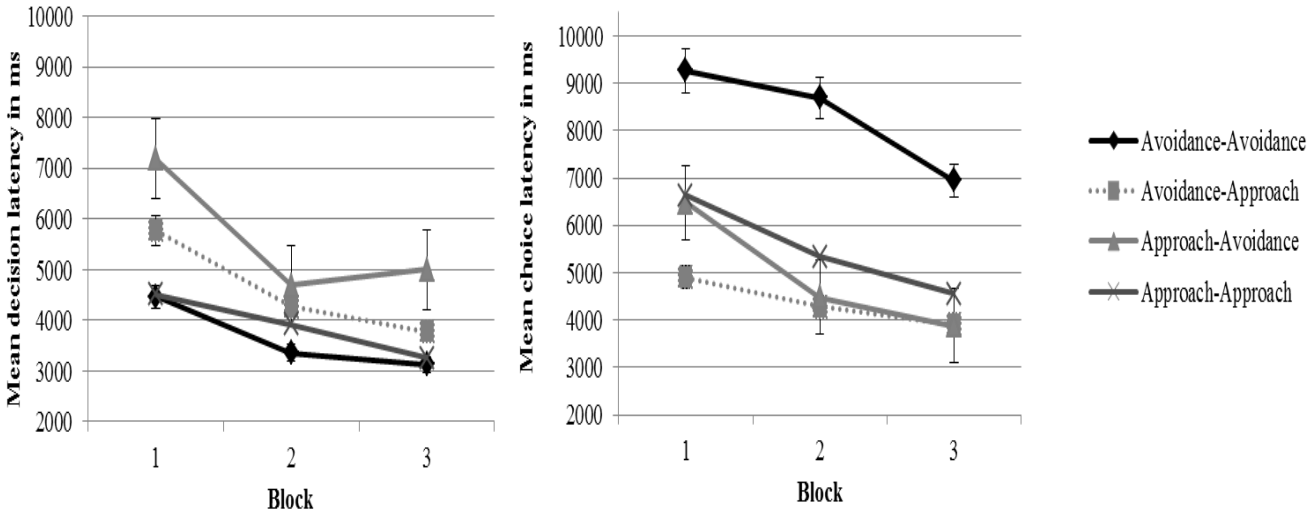

Figure II.1.4. Mean decision latency and choice latency.

Discussion

The objective of the current study was to investigate how different types of goal competition impact pain-related fear, decision-making behavior, and decision times. We hypothesized that avoidance-avoidance competition would lead to increases in pain-related fear and less eagerness to perform a movement as well as slowed down decision-making as opposed to approach-approach competition. Competition between a positive and a negative outcome would situate somewhere in between.

The results of this study can be readily summarized. First, pain-related fear was greatest for avoidance-avoidance competition, and least for approach-approach competition, whereas the opposite

was true for eagerness. Furthermore, it seems that especially the presence of pain increased pain-related fear, as participants were also more afraid of the avoidance-approach competition (pain and winning lottery tickets) than the approach-avoidance competition (safety and losing lottery tickets); whereas the prospect of winning lottery tickets seemed to increase eagerness, as indicated by the higher eagerness reported for the avoidance-approach competition compared to the approach-avoidance competition. Second, participants were less often prepared to perform movements associated with two concurrent negative outcomes and the most willing to perform movements associated with two positive outcomes. Furthermore, participants were also more willing to perform the movement associated with both pain and reward, than the movement associated with safety and loss of reward. Third, decision latencies showed that participants tended to be faster in deciding whether or not to perform a movement associated with two positive or two negative outcomes (approach-approach/avoidance-avoidance), compared to movements associated with one positive and one negative outcome (approach-avoidance/avoidance-approach). Especially when faced with the choice to perform a movement associated with safety and losing lottery tickets, decision latencies were increased. Fourth, when presented with approach-avoidance or avoidance-approach competition, participants chose to approach the movement associated with the positive outcome (earning tickets; safety), preferred to perform the movements associated with winning lottery tickets when presented with an approach-approach competition, and preferred losing tickets over the administration of pain in an avoidance-avoidance competition. Lastly, participants were slower in deciding which movement out of two to choose when being presented with two negative outcomes compared to all other competition types.

Taken together, the results support previous calls for the inclusion of a motivational perspective on pain-related fear and pain-related decision-making (Crombez et al., 2012; Eccleston & Crombez, 1999; Vlaeyen & Linton, 2012), suggesting that different types of goal competition influence pain behavior differently. Our findings are consistent with research of Miller (1944) and Murray (1975) indicating conflict behavior is more likely to arise when at least one avoidance goal is at play, and in line with the finding that experiencing goal conflict is associated with higher self-reported pain-related fear (Karoly et al., 2008) and higher reported pain (Hardy et al., 2011) in patients with chronic pain. As suggested by Schrooten et al. (2014), it seems that being hemmed in by two aversive outcomes might explain the oscillatory behavior often displayed by patients (Huijnen et al., 2011).

However, participants did not only display more conflict or hesitant behavior when confronted with two concurrent negative outcomes; they also displayed a rather large preference for winning lottery tickets over safety and faster decision-making when these outcomes where presented concurrently. Given that choice latency is considered one possible indicator of conflict strength, it seems that participants might have experienced the choice between these two positive or desirable

outcomes as less of a conflict (Diederich, 2003). This finding may have been due to a possible inequality in desirability or valence between the positive outcomes. One possible explanation might lie in the operationalization of our 'safety'-outcome, which was defined as the absence of painful electrocutaneous stimulation, but encompassed not receiving any of the other outcomes as well. This finding illustrates and extends the notion that equality in desirability or strength of valence is an important factor to take into account when dealing with decision making under conflict (Diederich, 2003; Miller, 1944; Vlaev, Chater, Stewart, & Brown, 2011). This might also be due to individual differences in the perceived probability of each of the outcomes, despite the fact that all participants learned the contingencies in the acquisition phases. Future studies might want to explore the effects of differences in equality and perceived probability on the experience on conflict by installing variation in the desirability and probability of different outcomes between and within subjects, by for example re-evaluating (inflating or devaluating) the outcomes (Baeyens, Eelen, Van den Bergh, & Crombez, 1992; Walther, Gawronski, Blank, & Langer, 2009) or introducing variations in the probability of receiving painful stimulations ranging from low ('safe') to high ('dangerous'), and likewise, variations in the probability of monetary gain or loss. Another possibility to explore effects of perceived probability, is to assess this for each outcome (e.g., immediately before a movement, or at the start of a block) by including a measure of expectancy.

Three types of goal competition can be distinguished based on the valuation of the outcome (Diederich, 2003; Gray, 1975). As such, administering a positive stimulus, abating an aversive stimulus, or omitting an aversive stimulus acquire a positive valence; whereas taking away or leaving out a positive stimulus, or presenting an aversive stimulus acquire negative valence. Furthermore, each of the operationalisations is believed to correspond with a specific emotional or affective meaning. Receiving a positive stimulus is associated with joy, whereas omitting it results in frustration and taking it away in disappointment. Receiving an aversive stimulus may cause fear, whereas the omission results in a feeling of safety, and taking it away in relief (Gray, 1975; Mowrer, 1960). Despite the myriad of possibilities, most experimental research on goal conflict however focused on the administrating either negative or positive stimuli, to induce goal competition (Kimble, 1961), whereas research on decision-making under conflict mainly targeted the administration or removal of a reward (Tversky & Kahneman, 1992). The present study builds on the existing literature and extends it by employing both positive and negative stimuli, as well as the administration and the omission or removal thereof. This might more closely resemble situations of competition experienced by patients with chronic pain, who often choose to withdraw from activities they enjoy in order to avoid further harm, thus missing out opportunities that are pleasurable. As Karoly (2015) formulated it, these types of operationalization might be a good way to study the "goal prioritization decision" of patients. For example, for a patient with chronic pain whose job requires a lot of lifting, frequently going to work might worsen his pain—which is a short term negative outcome—but it also guarantees his income–

which is a delayed positive outcome. Our results indicate that when competition arises between two negative outcomes—such as pain exacerbation and social exclusion, for example—may make participants feel more indecisive and display more hesitant behavior. We believe that it is likely that patients display similar oscillatory/hesitant behavior, but obviously replication of this study with patients is needed.

Some limitations should be considered. First, we tested our hypotheses in a sample of healthy, pain-free students by experimentally inducing pain. Therefore, the results of the study cannot be readily translated to a general population, let alone to individuals with chronic pain. Similar concerns might be raised about the ecological validity of the use of lottery tickets and monetary incentives to induce approach motivation, although they have been proven successful in previous experimental research (Claes, Crombez, & Vlaeyen, 2015; Claes et al., 2014; Talmi et al., 2009). Second, we explored differences when two concurrent goals were competing, but the influence of other variables (e.g., goal importance or preference) and goals that are not directly related to the conflicting goals would merit from further scrutiny. For instance, the goal to end the experiment and collect the financial reimbursement may have played a role in the decision process of participants (Barker, 1942; Miller, 1944). Third, in the present study, participants were presented with different conflicts in randomized order and did not receive any of the outcomes when making their choice. An interesting avenue for future studies might be to explore how previously presented conflicts and the solution thereof, influence participants' expectations and future choice behavior. Fourth, in the present design, we only included self-reported measures, such as pain-related fear, and behavioral responses such as decision-making behavior. Using self-reported measures may have created an instructional set. Therefore, it might be interesting to also include more direct measurements of avoidance, as well as a psychophysiological indication of fear (such as the eye blink startle response; Lang & McTeague, 2009), or arousal (such as pupil dilatation; Bradley, Miccoli, Escrig, & Lang, 2008), and the underlying neural mechanisms of goal competition when confronted with pain (Wiech & Tracey, 2013).

In sum, this study provides experimental evidence for the differential impact of different types of goal competition on pain-related fear and pain-related decision-making, with conflicts involving two negative outcomes evoking more fear and greater difficulties in making a choice than other types of competition. The current study was one of the first to incorporate existing theories on decision-making and goal competition, and testing their implications in the field of pain. It seems that there is some truth in British philosopher Jeremy Bentham's (1748-1832) words when he wrote: "*Nature has placed mankind under the governance of two sovereign masters, pain and pleasure. It is for them alone to point out what we ought to do, as well as to determine what we shall do."* (Bentham, 1789, p. 1). However, further experimental inquiry to improve our understanding of (pain-related) goal conflict and goal competition on decision-making and pain-related behavior is imperative.

PART III:

The impact of environmental cues predicting (dis)similar outcomes on pain-related fear and avoidance behavior

CHAPTER III.1

The impact of cues predicting pain versus reward on pain-related fear and avoidance behavior

Abstract

It has been argued that pain-related fear and avoidance behavior occur in a context of multiple, sometimes competing, demands. Individuals experiencing pain might be motivated to avoid further harm, but might equally be challenged by other demands. Previous research shows that goal-directed behavior might be modulated by the presence of cues that predict (dis)similar outcomes. However, literature investigating this in the field of pain is scarce. Therefore, this experiment investigated whether environmental cues predicting pain and reward modulate pain-related fear and avoidance behavior. Forty-eight healthy participants completed a movement task with two different joystick movements. One movement was associated with a painful stimulus, whereas the other movement was associated with a reward, i.e., lottery tickets. In the second phase, participants learned to associate three different Pavlovian cues with the painful outcome, the rewarding outcome, or neither of the two. In the third phase, these Pavlovian cues were integrated in the movement task. This study demonstrates that aversive cues enhance and appetitive cues reduce pain-related fear and avoidance behavior. Taken together, these results provide experimental evidence that Pavlovian cues are capable of modulating fear and avoidance behavior in a pain context.

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Introduction

Being goal-directed, and simultaneously pursuing multiple goals is a characteristic of human life (Emmons, 1986). Recently, theorists have argued in favor of a motivational approach which considers pain and suffering in the context of multiple demands (Eccleston & Crombez, 1999; Van Damme et al., 2008; Vlaeyen & Linton, 2012). Indeed, evidence is accumulating that attention to pain, pain-related fear and pain avoidance are not static, but profoundly affected by the presence of other, competing goals (Schrooten & Vlaeyen, 2010; Van Damme et al., 2012). In a context with multiple goals, concurrent goals might conflict with each other, and the presence of a competing goal may impede the pursuit of another goal (Boudreaux & Ozer, 2012; Shah, Friedman, & Kruglanski, 2002). Pain is considered to be a salient and biologically relevant aversive stimulus that most individuals want to avoid, reduce or limit its impact when present (Den Hollander et al., 2010; Eccleston & Crombez, 1999; Vlaeyen, 2015). One of the most debilitating consequences of experiencing pain is the withdrawal from other, valued activities. For instance, a recent study demonstrated that introducing an aversive painful stimulus concurrent with a reward, decreases the motivation to put effort in obtaining the reward (Gandhi et al., 2013), and that pain or the attention demanded by pain is indeed capable of interfering with other, valued activities (Notebaert et al., 2011). Conversely, engaging in other tasks reduces attention to pain (Schrooten, Van Damme et al., 2012), and is even capable of reducing the experience of pain (Verhoeven et al., 2010), indicating that pleasurable activities can be potent motivators as well. Take for example an individual's wish to increase muscle tone might persist in exercising, despite the physical distress they experience.

Not only is our behavior characterized by goal-directedness, but it can also be modulated by environmental cues (Doya, 2008). Although previous studies demonstrate the context-dependent nature of attention, fear and avoidance, it is largely unknown how situational factors influence the decision to avoid further harm or to pursue pleasurable activities. One intriguing mechanism that has demonstrated the cue-controllability of behavior is Pavlovian-to-Instrumental Transfer (PIT). PIT refers to the capacity of Pavlovian cues (conditioned stimuli; CSs) to modulate the vigor of instrumental actions. Two types of PIT can be discerned: When Pavlovian cues predict a similar outcome as one of the instrumental responses, instrumental responding that is associated with that outcome increases, which is called specific PIT; whereas a non-selective increase in instrumental responding motivated by a conditioned Pavlovian cue is termed general PIT (Cohen-Hatton et al., 2013; Holmes et al., 2010; Talmi et al., 2008). The PIT effect is well established in non-human animals (Balleine & Ostlund, 2007; Dickinson & Balleine, 2002; Estes, 1943; Lovibond, 1983; Rescorla & Solomon, 1967); and has also been documented in humans (Bray, Rangel, Shimojo, Balleine, & O'Doherty, 2008; Geurts, Huys, den Ouden, & Cools, 2013; Huys et al., 2011; Staats & Warren, 1961; Talmi et al., 2008), but largely in a context of approach behavior. To date, there is only a limited number of studies that investigated the impact of *aversive* Pavlovian stimuli on behavior

(Geurts et al., 2013; Huys et al., 2011). Despite accumulating evidence for the importance of environmental influences on behavior, there is a need for more research to further our understanding about the maintenance of dysfunctional avoidance behavior (Lewis et al., 2013; Van Meurs, Wiggert, Wicker, & Lissek, 2014).

Therefore, the current experiment was set out to investigate the impact of environmental cues on pain-related responding. For this purpose, we created an experimental set-up following a similar structure as a PIT-procedure, containing an instrumental learning phase, a Pavlovian learning phase, and a subsequent test phase in which the Pavlovian cues are integrated. Our design is however also conceptually different from a typical PIT procedure. First, we incorporated both pain and reward (lottery tickets) as outcomes associated with the movements. This is relatively novel, as most studies only incorporate appetitive outcomes, and allows us to uncover whether cues predicting pain selectively enhance fear and avoidance of painful movements—resembling a specific PIT effect—or reduce pleasure and approach for appetitive actions—reflecting a general PIT effect. Second, we included three Pavlovian stimuli, associated with either pain, reward, or neither of the two, allowing for a direct comparison between different types of stimuli. Non-presentation of a CS serves as a baseline. Furthermore, this design allows creating different types of movement-cue pairings, each possibly producing different types of competition between the outcome predicted by the movement and the outcome predicted by the cue. Previous work in our lab has demonstrated that especially avoidance-avoidance competition—being presented with two negative outcomes—increases fear and avoidance (Claes, Crombez, Meulders, & Vlaeyen, 2015). Third, and most importantly, our main dependent variables are acquired fear responding and avoidance behavior operationalized as choices and response latencies, rather than instrumental responding. We expected that presenting a cue predicting a painful outcome would generally increase pain-related fear and avoidance, whereas cues predicting reward would generally decrease pain-related fear and avoidance as compared to neutral cues or the absence of cues. Furthermore, we expected that presenting an incongruent cue—that is, presenting a reward cue with the painful movement or a pain cue with the reward movement—would result in more hesitant behavior, as it may bring about both approach and avoidance tendencies (Claes, Crombez, Meulders, et al., 2015).

Methods

Participants

Forty-eight healthy individuals (35 female; mean age 21.42 years [SD = 4.58]) took part in order to earn € 8 or to fulfil course requirements. Exclusion criteria during the recruitment were: insufficient knowledge of the Dutch language, cardiovascular diseases, lung diseases, neurological diseases (e.g., epilepsy), other serious medical conditions, chronic or acute pain of the wrist or related body regions, being asked to avoid stressful situations by a general practitioner, presence of electronic

medical devices (e.g., pace-maker), pregnancy, hearing problems and impaired vision that is not corrected (including color blindness). Some participants were excluded for additional a priori stated criteria. One participant was unable to handle the joystick correctly. Another participant failed to learn the necessary contingencies. Two participants indicated that both pain-avoidance and earning tickets were unimportant to them. All participants provided informed consent. The experimenter (female; N.C., L.M.) emphasized that participants could refrain from participating at any time. The Ethical Committee of the Faculty of Psychology and Educational Sciences of the KU Leuven (Belgium) approved the experimental protocol. The final sample consisted of 44 participants, of which 33 were female (M_{age} = 20.73, SD_{age} = 2.76).

Apparatus

A Windows XP computer (Dell OptiPlex 755, Dell, Round Rock, TX) with 2 GB Random-access memory (RAM) and an Intel Core2 Duo processor (Intel, Santa Clara, CA) at 2.33 GHz and an ATI Radeon 2400 graphics card (Advanced Micro Devices, Sunnyvale, CA) with 256 MB of video RAM was used to run the experiment, which was programmed in Affect, version 4.0 (Spruyt et al., 2010).

Procedures and Stimuli

We employed a procedure that followed a similar structure as studies on Pavlovian-to-instrumental transfer (Cohen-Hatton et al., 2013; Talmi et al., 2008), which comprises of two different experimental tasks, namely an instrumental joystick movement task (Meulders & Vlaeyen, 2013b) and a Pavlovian learning procedure. For an overview of the procedure, see Figure III.1.1.

In the *instrumental joystick movement task*, an arrow in the middle of the screen pointing either towards the left or towards the right served as a discriminative stimulus (SD). Participants carried out movements (Response, R) with their dominant hand using a Paccus Hawk Joystick (Paccus Interfaces BV, Almere, The Netherlands). The outcome associated with the movements was either a painful electrocutaneous stimulus (painful outcome; O_p) or lottery tickets (reward outcome; O_r). The painful stimulus (painful outcome; O_p) was a 1500 ms Electrocutaneous Stimulus (ECS), consisting of trains of 30 ms sinusoid pulses, administrated on the wrist of the dominant hand through surface SensoryMedics electrodes (1 cm diameter; SensorMedics Corp, San Diego, CA) filled with K-Y gel (Johnson & Johnson, New Brunswick, NJ). The ECS was delivered by an Isolated Bipolar Current Stimulator (DS5; Digitimer ltd, Welwyn Garden City, England). The intensity of the ECS was individually determined during a calibration procedure (see Preparation phase). The lottery tickets (reward outcome; O_r) represented a prize worth approximately € 100 that was chosen by the participant out of a list of possible prizes. A movement in one direction (e.g., left) resulted in the

administration of the O_p, whereas a movement in the other direction (e.g., right) resulted in receiving the O_r.

In the *Pavlovian learning procedure*, circles in three different colors (yellow, pink, and orange) served as conditioned stimuli (CSs). These CSs were presented in the middle of the screen. Each stimulus was followed by an unconditioned stimulus. The unconditioned stimuli (USs) were identical to the O_p and O_r from the joystick movement task. Therefore, we refer to the USs as O_p and O_r. Similarly, the O_p followed one circle (e.g., pink), the O_r another (e.g., yellow), and the last circle was not associated with either of the outcomes (e.g., orange).

In the test phases of the experiment, the CSs were integrated in the instrumental joystick task. For this purpose, we created 6 new SD-CS configurations, namely left-pink, left-orange, left-yellow, right-pink, right-orange, and right-yellow (for an example, see Fig.III.1.1, 'choice phase'). During choice trials of the transfer phase, participants were presented with juxtaposed SDs, which were either presented without a CS, or accompanied by the pain CS, the reward CS, the neutral CS, with a congruent cue, i.e., the pain-SD with the pain-CS and the reward-SD with the reward-CS, or 3) with an incongruent cue, i.e., the pain-SD with the reward-CS and the reward-SD with the pain-CS (for an example, see Figure III.1.1, 'transfer phase').

Measures

Self-reported measures

Rating electrocutaneous stimulus. Participants rated the pain intensity ("pain intensity"), unpleasantness ("pain unpleasantness"), and tolerance ("pain tolerance") of the selected ECS using an 11-point Likert-scale ranging from 0 (not at all) to 10 (very much) immediately after calibrating the stimulus. Pain intensity was also assessed using a verbal rating scale: participants had to select one of four words that matched their experience ("light"-"medium"-"serious"-"enormous").

Rating lottery ticket. Participants reported how valuable ("ticket value") and how pleasant ("ticket pleasantness") they found the tickets using a 11-point Likert-scale ranging from 0 (not at all) to 10 (very much).

Goal prioritization. Participants a priori indicated which goal they considered most important: pain-avoidance, reward-seeking, both equally important, or both equally unimportant. Participants indicating both goals were equally unimportant were excluded from further analyses.

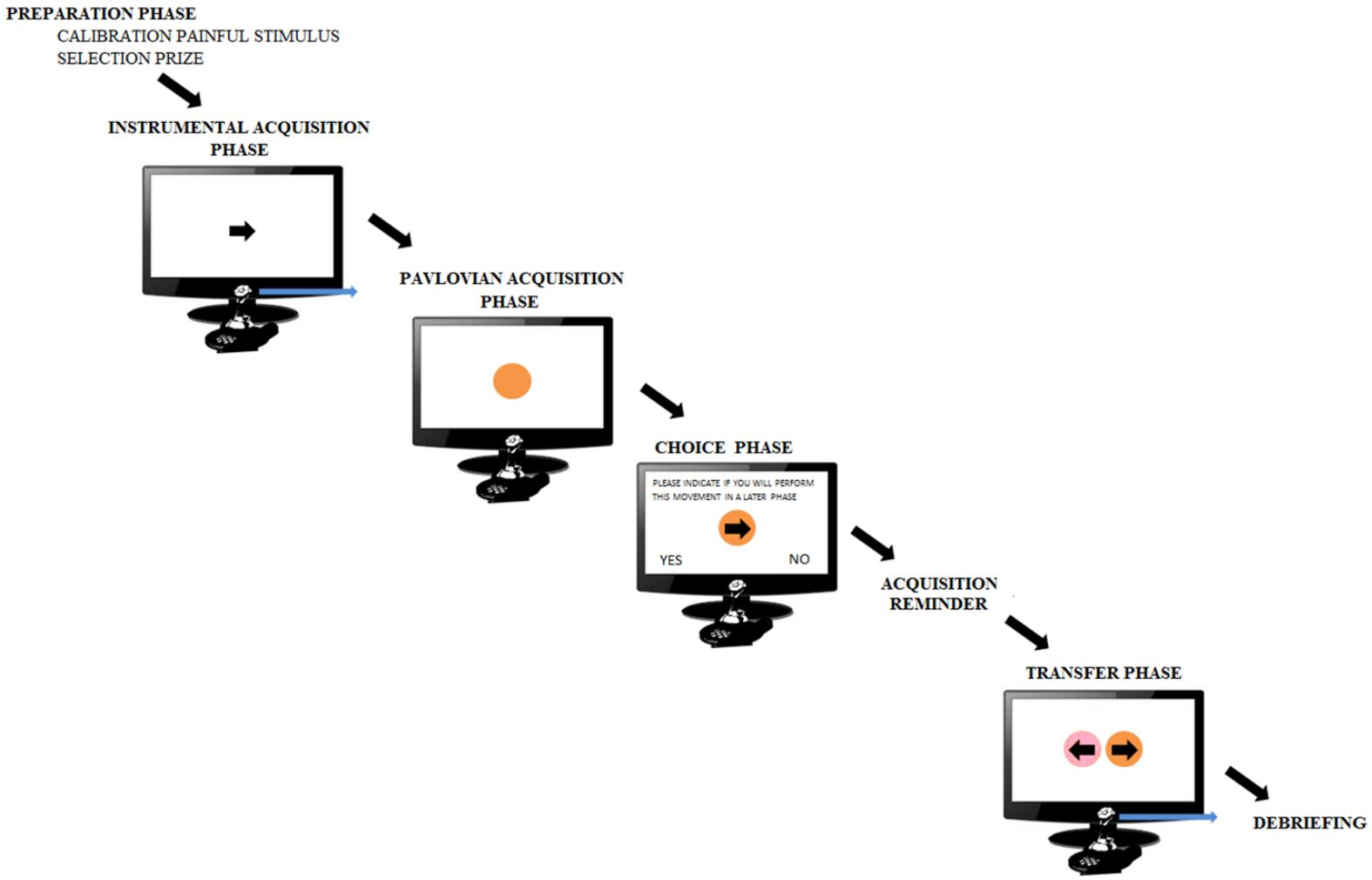

*Figure III.1.1.*Overview of the procedure. A movie clip of the experimental procedure is available in the online version of this dissertation by clicking the figure.

Manipulation check: pain and ticket expectancy. Participants retrospectively indicated to what extent they expected painful electrocutaneous stimulation ("pain expectancy") and lottery tickets ("ticket expectancy") for each SD type and CS type using an 11-point Likert scale ranging from 0 (not at all) to 10 (very much). For this purpose, the SD and/or CS was presented visually, along with the presentation of the question on top of the screen and a rating scale at the bottom of the screen participants could click.

Pain-related fear and eagerness. Participants reported how afraid ("pain-related fear") and how eager they were to perform the movement ("eagerness") for each SD type using an 11-point Likert scale ranging from 0 ('not at all') to 10 ('very much').

Decision making behavior. Participants verbally reported whether or not they wanted to perform the depicted movement in a later phase of the experiment. Participants could either select 'yes' or 'no' as an answer. 'Yes' was coded as 1, whereas 'no' was coded as 0. Per block and per SD type and SD-CS configuration, the number of times participants were willing to perform the depicted movement was summated.

Behavioral responses

Decision latency. Decision latency was operationalized as the time from stimulus presentation (SD or SD-CS configuration) until participants indicated whether they would perform the presented movement in a later phase of the experiment.

Choice behavior. On choice trials, participants were given the possibility to perform only one of the movements represented. As an index of choice behavior, the number of times the reward movement was chosen was summated per block and per type of choice trial.

Choice latency. Choice latency was recorded for every choice, and was defined as the time between presentation of both symbols and the performance of the selected movement.

Procedure

The experimenter informed participants that the experiment consisted of 7 phases and lasted about 60 minutes.

Preparation phase

First, the intensity level of the electrocutaneous stimulus was individually determined. The experimenter instructed participants to select a stimulus that was painful and required some effort to tolerate. They were also informed that painful electrocutaneous stimuli of increasing intensity would be administered repeatedly. Participants could indicate when they no longer wanted to increase stimulus intensity, and agreed upon receiving painful stimuli of maximally the selected intensity during the remainder of the experiment. Participants assessed pain intensity, unpleasantness and tolerance of the selected stimulus. Subsequently, participants were informed that they could earn

lottery tickets for a lottery during the experiment. With this lottery, they could win a prize of their choice, selected out of a list of possible prizes. Additionally, participants rated ticket value and ticket pleasantness.

Instrumental acquisition phase

Participants were instructed to perform the movements as indicated by the arrow (SD) as soon as the arrow appeared in the middle of the screen. Prior to the acquisition phase, participants practiced the joystick movements, without the pain and reward outcome. There was one block of 2 left movements, and 2 right movements. Next, participants were informed that one movement (painful movement, M_p) would be paired with a painful outcome of maximally 75% of the selected stimulus intensity, whereas another movement (reward movement, M_r) resulted in receiving lottery tickets. In reality, participants always received the same stimulus intensity, that is, 75% of the selected stimulus intensity. Movements were reinforced in 67% of the trials. This phase consisted of 2 blocks of 3 movements in each movement direction, i.e., 2 (3 M_r, 3 M_p). Upon completion of these blocks, a contingency check was administered. More specifically, participants were presented with each of the SDs, and had to indicate what this movement predicted: pain, reward or nothing. If participants did not learn the associations, they could perform a maximum of 4 additional blocks. When acquisition was successful, participants assessed pain-related fear and eagerness for both movements. A trial comprised of a 1 s-presentation of the fixation cross, followed by the presentation of the SD, upon which participants performed the depicted movement. Depending on participant's movement speed, movement completion varied in length. Inter Trial Intervals (ITI) were 5s in duration.

Pavlovian acquisition phase

Participants were instructed to look at the middle of the screen, where circles of three different colors would appear. Participants were told that one color would be associated with an electrocutaneous stimulus of maximally 75% of the selected stimulus intensity (CS_p), another color with the lottery tickets (CS_r), and yet another color would not be paired with either of the two ($CS_{neutral}$). Reinforcement rate was 67%. Similar to the previous phase, participants completed 2 blocks of 3 presentations of each CS, that is, 2 (3 CS_p, 3 CS_r, 3 $CS_{neutral}$). Participants could complete up to 4 additional blocks until the contingencies were successfully learned—that is, successfully identified what each of the CSs predicted—or were otherwise excluded from the experiment. Lastly, participants reported pain-related fear for each of the CSs. A trial consisted of a 1 s-presentation of the fixation cross, followed by the presentation of the CS, and a 5s-ITI.

Choice phase

The experimenter informed participants that in this phase, the CSs would be integrated in the movement task. The experimenter requested that participants chose whether or not they would perform the depicted movement in a later phase of the experiment, in which they could receive painful

electrocutaneous stimuli of maximally the selected intensity (100%), as well as lottery tickets. However, participants were informed that they would not receive any electrocutaneous stimulation nor lottery tickets when making their choice during this phase. Participants completed 3 blocks of one presentation of both SDs presented alone, as well as all SD-CS configurations. Note that two SDs or two CSs were never presented together. For every trial, decision making behavior and decision latency were recorded.

Acquisition reminder

To avoid extinction of the contingencies, participants completed 1 reinforced trial of each SD movement and each CS.

Transfer phase

The same 8 symbol presentations—both SDs and all SD-CS configurations—as in the choice phase were used. Participants were again requested to perform the movements as indicated on screen. The experimenter emphasized that in this phase participants would be presented with the outcomes again. More specifically, participants were informed that now the painful electrocutaneous stimulus could be their maximally selected intensity, as well that they could earn more lottery tickets. Two different types of trials were presented. First, *standard trials*, in which participants were presented with one symbol presentation and had to perform the depicted movement. For some of the trials, pain-related fear and eagerness were assessed prior to performing the movement. Second, *choice trials*, in which participants were presented with both movements, presented with or without a CS, and participants had to choose and perform one of both movements (see Procedures and Stimuli). In total, participants completed 3 blocks of 2 standard trials per symbol presentation (16 trials), and 1 choice trial per two juxtaposed symbol-presentations (6 trials). During all choice trials, choice behavior and choice latencies were recorded.

Debriefing

Participants were informed about the course of the lottery and were debriefed about the objective of the experiment. Participants could leave their contact information to be contacted if they had won the prize and/or if they wished to be informed about the results of the current study. A winner was selected at random by the computer.

Results

Data processing and statistical analyses

To test our hypotheses, Repeated Measures ANOVAs were carried out for the choice and transfer phase, and when appropriate, were followed up with planned comparisons using a Bonferroni correction. All statistical analysis were run with SPSS 22.0 (IBM Corp, 2013). Whenever necessary, Greenhouse Geisser corrections were reported. As a measure of effect size, generalized eta squared (η_G^2) was calculated (Bakeman, 2005; Lakens, 2013; Olejnik & Algina, 2003).

Descriptive statistics

The average intensity of the painful electrocutaneous stimulus was 11.61 mA (*SD* = 5.34). The mean pain intensity was 8.43 (*SD* = 1.07), mean pain unpleasantness 8.5 (*SD* = 1.11), and the mean pain tolerance 8.05 (*SD* = 1.14). The mean ticket value was 6.46 (*SD* = 2.14), and the mean ticket pleasantness 7.52 (*SD* = 1.92). Twelve participants indicated that their most important goal was pain-avoidance, 15 indicated that reward-seeking was most important, and 17 participants found both goals equally important.

Manipulation check: pain and ticket expectancy

2 (SD type [reward/pain] × 4 (CS type [reward/pain/neutral/none]) Repeated Measures ANOVAs revealed that participants expected the painful stimulus more for the SD associated with the painful outcome than during the SD associated with the reward outcome, main effect SD type, F (1,43) = 227.63, $p < .001$, $\eta_G^2 = .515$. A main effect of CS type, F (3,43) = 41.5, $p < .001$, $\eta_G^2 = .244$, was also found, indicating that participants expected the painful stimulus more when the CS_p was presented, compared to one of the other CSs. The SD type × CS type interaction was also significant, F (3,43) = 19.42, $p < .001$, $\eta_G^2 = .082$, indicating that a pain CS was associated with a further increase in pain expectancy for both painful and rewarding movements. Similar results were found for ticket expectancy: a significant main effect of both SD type, F (1,43) = 189.84, $p < .001$, $\eta_G^2 = .428$, and CS type, F (3,43) = 67.13, $p < .001$, $\eta_G^2 = .309$, were found, indicating that participants also successfully learned which SD and which CS predicted the lottery tickets. There was again a significant interaction between SD and CS type, F(3,43) = 15.79, $p < .001$, $\eta_G^2 = .07$, showing that when a reward CS was presented, participants expected the reward more for both the painful and the reward movement.

Pain-related fear and eagerness

The results for pain-related fear and eagerness are presented in Figure III.1.2. 2 × 4 × 3 (SD type × CS type × Block) Repeated Measures ANOVAs for pain-related fear yielded a main effect of SD type, F (1,43) = 295.13, p < .001, η_G^2= .556, indicating that participants overall were more afraid to perform the painful movement than the reward movement. A main effect of CS type, F (3,43) = 183.05, p < .001, η_G^2=.326, and a main effect of block, F (2,43) = 15.78, p < .001, η_G^2= .033, were found. The interaction between SD and CS type was also significant, F (3,43) = 63.21, p < .001, η_G^2=.121, as was the interaction between SD type and block, F (2,43) = 7.3, p < .001,η_G^2= .009 (See Figure III.1.2, top plane). None of the other interactions were significant. Analysis revealed that participants were most afraid of a painful movement when combined with the CS_p, compared to when the CS was absent, t(43) = 3.14, p < .001, which in turn elicited more fear than when accompanied by the $CS_{neutral}$, t(43) = -3.20, p < .001; the latter did not differ from the CS_r, t(43) = -1.98, p = .054. Similarly, for the reward movement, results showed that when it was combined with the CS_p, participants were more afraid compared to when there was no CS presented, t(43) = 14, p < .001. There was no difference in reported pain-related fear between presenting the reward movement with a $CS_{neutral}$, CS_r or without a CS, t < 1.

Furthermore, the results showed that participants were more eager to perform the reward movement than the painful movement, main effect of SD type, F (1,43) = 289.91, p < .001, η_G^2= .525. There was also a main effect of CS type, F (3,43) = 121.14, p < .001, η_G^2= .284. The main effect of block however was not significant, F (2,43) = 1.67, p = .2,η_G^2= .003. There was an SD type × CS type interaction, F (3,43) = 28.67, p < .001, η_G^2= = .085 (see Fig.III.I.2, bottom plane), an SD type × block interaction**,** F (2,43) = 7.84, p < .001, η_G^2= .012, and an interaction between CS type and block, F (6,43) = 4.62, p = .001, η_G^2= .009. The SD type × CS type × block interaction did not reach significance**,** F (6,43) = 1.52, p = .186, η_G^2=.003. Further analyses revealed that participants were the least eager to perform the *painful movement* when accompanied with a CS_p compared to when there was no CS presented, t(43) = -9.08, p < .001, which elicited less eagerness than a $CS_{neutral}$, t(43) = 4.07, p < .001 which in turn elicited less eagerness than a CS_r was presented , t(43) = 4.83, p < .001. Participants were the least eager to perform the *rewarding movement* when it was accompanied with the CS_p compared to when there was a $CS_{neutral}$ presented, t(43) = -9.9, p < .001, which in turn elicited less eagerness than a presentation without a CS, t(43) = -2.34, p < .001, which did not differ from eagerness reported for the reward movement with the CS_r, t(43) = 1.02, p = .315.

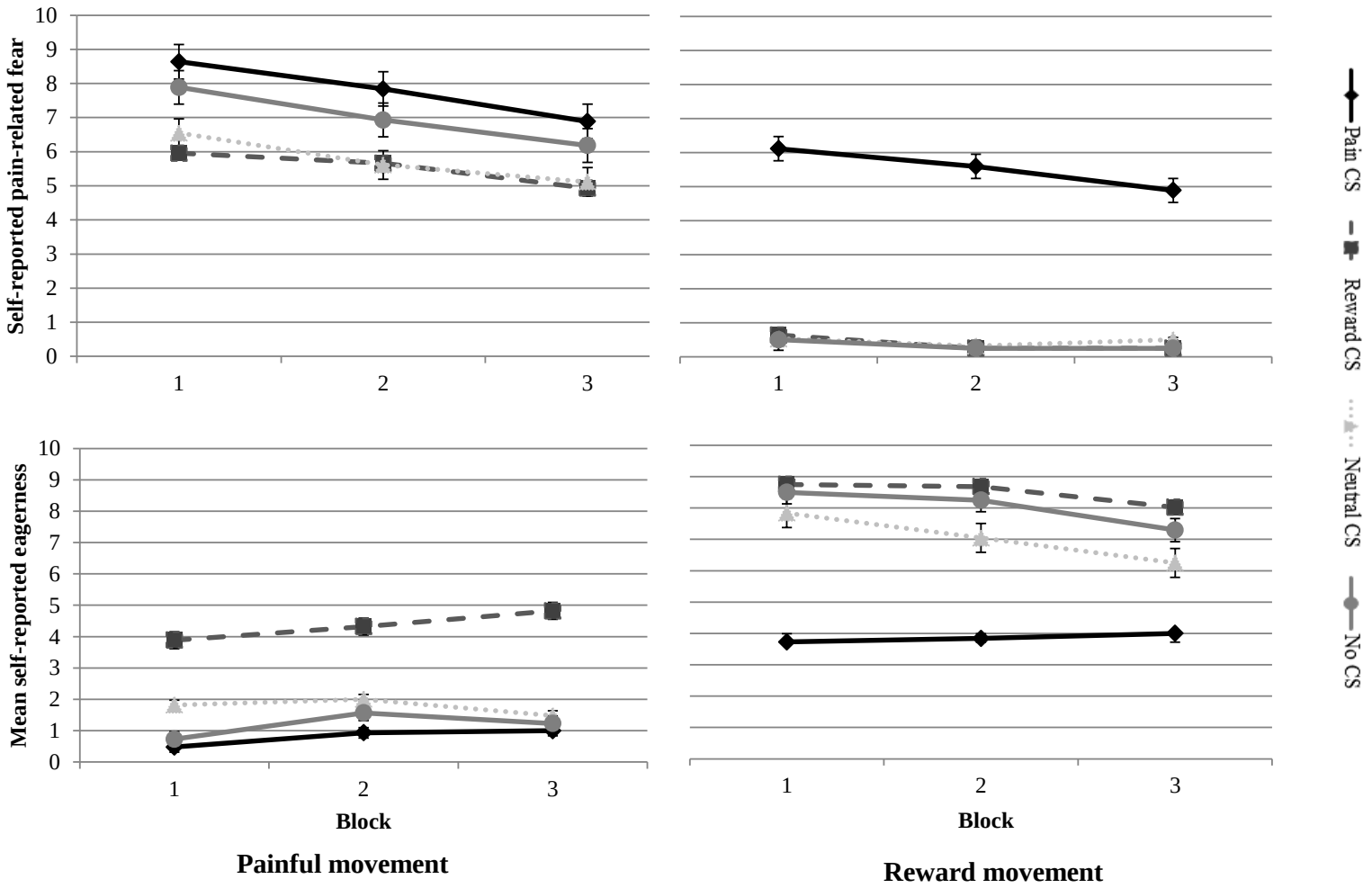

Figure III.1.2. Mean self-reported pain-related fear (top) and eagerness (bottom). Mean scores (± SDs) for both the painful and reward movement per CS type (pain/reward/neutral/none) and per block during the transfer/test phase are presented.

(Avoidant) Decision making behavior

For decision making behavior, 2 × 4 × 3 (SD type [reward/pain] × CS type [reward/pain/neutral/none] × Block [1/2/3]) Repeated Measures ANOVAs showed that there was a main effect of SD type, F (1,43) = 111.08, p < .001, η_G^2= .424, indicating that participants chose to perform the reward movement more often than the painful movement. Furthermore, there was a main effect of CS type, F (3,43) = 70.85, p < .001, η_G^2= .2, and an interaction between these variables, F (3,43) = 11.24, p < .001, η_G^2= .06. The main and interaction effects with the variable Block were all non-significant. Further analysis showed that there was no significant difference in the number of times participants indicated to be willing to perform the *painful movement* in a later phase when a CS_p was presented compared to the absence of a CS, t(43) = -1.43, p = .16, which in turn did not differ from the presentation of a $CS_{neutral}$, t(43) = 1.35, p = .183. Participants however indicated that they wanted to perform the painful movement in a later phase more often when a CS_r was presented, compared to a CS_p: t(43) = -6.03, p < .001; a $CS_{neutral}$: t(43) = 5.5, p < .001, and no CS: t(43) = 5.2, p < .001. For the *reward movement*, participants less often indicated that they would perform the movement in a later phase when a CS_p was presented, compared to no CS, t(43) = -4.48, p < .001, a $CS_{neutral}$, t(43) = -4.48, p < .001, and a CS_r, t(43) = -5.2, p < .001. There was no significant difference between the latter three CS types, all p > .183. In Table III.1.1, the number of participants (in both frequencies and percentages) choosing to perform the depicted movement in a later phase is presented per SD, CS, and block.

Decision latency

Repeated measures ANOVAs showed that there was no main effect of SD type, F (1,43) = 1.16, p = .287, η_G^2= .001, for the time participants took to make a decision. There was however a main effect of CS type, F (3,43) = 8.46, p < .001, η_G^2= .021, and a main effect of block, F (2,43) = 39.1, p < .001, η_G^2=.054. We also found an SD × CS type interaction, F (3,43) = 9.22, p = .001, η_G^2=.03 (See Figure III.1.3). The other interactions were non-significant. Planned contrasts revealed that participants were initially (block 1) slower in making a decision when the movement was accompanied with an *incongruent* CS, or in other words, when competition between the pain and reward outcome was introduced into the trial (for the *painful* movement: CS_r vs. CS_p: t(43) = -3.73, p = .001, vs. $CS_{neutral}$: t(43) = 3.24, p = .002, and vs. no CS: t(43) = 3.83, p < .001; for the *reward* movement: CS_p vs. CS_r: t(43) = 2.06, p = .005, vs. $CS_{neutral}$: t(43) = 2.18, p = .035, and vs. no CS: t(43) = 3.49, p = .001). These effects however disappeared over time (cf. block 3).

Table III.1.1

Number and percentage of participants that chose to perform the depicted movement per SD, CS, and block during the choice phase

		block 1		block 2		block 3	
SD	CS	Freq	%	Freq	%	Freq	%
Pain	Pain	3	6.8	2	4.5	3	6.8
	Reward	25	56.8	24	54.5	26	59.1
	Neutral	8	18.2	5	11.4	6	13.6
	None	5	11.4	5	11.4	5	11.4
Reward	Pain	25	56.8	21	47.7	20	45.5
	Reward	42	95.5	43	97.7	44	100
	Neutral	39	88.6	40	90.9	39	88.6
	None	39	88.6	40	90.9	41	93.2

Note. Freq = Frequency, number of participants; SD = discriminative stimulus; CS = Pavlovian conditioned stimulus. 44 participants were included in the analyses. The percentage is calculated based on the total number of participants, per SD-CS configuration per block.

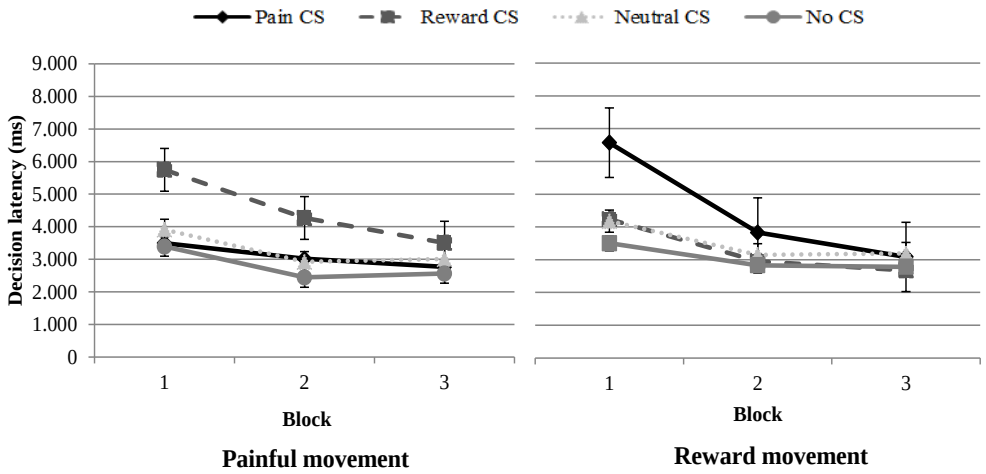

Figure III.1.3. Decision latencies. Average time (± SDs) needed to choose whether or not to perform the depicted movement (in ms) for both SD types (painful/reward movement), all CS types (pain/reward/neutral/none) and per block during the choice phase.

Choice behavior

6 (cue[pain CS/ reward CS/ neutral CS/ without CS/ congruent CS/ incongruent CS]) × 3 (block) Repeated Measures ANOVAs showed that participants chose to perform the reward movement less often when both SDs were presented with their incongruent CS, compared to all other contextual cues, main effect of cue, F (5,43) = 15.43, $p < .001$, η_G^2=.098. There were no significant effects with the block variable, all : $F < 1$. Planned comparisons further corroborated this finding: when comparing the SDs presented with their incongruent CSs to all other pairings, participants chose the reward movement less often, all $p < .001$. Table III.1.2 presents the number (frequencies) and percentage of participants choosing to perform the reward movement per context cue and block.

Table III.1.2

Number and percentage of participants that chose to perform the reward movement during choice trials of the transfer phase

		block 1		block 2		block 3	
CS1	CS2	Freq	%	Freq	%	Freq	%
Pain	Pain	39	88.6	40	90.9	40	90.9
Reward	Reward	41	93.2	41	93.2	40	90.9
Neutral	Neutral	39	88.6	40	90.9	38	86.4
None	None	43	97.7	43	97.7	42	95.5
Pain	Reward (congruent)	40	90.9	39	88.6	42	95.5
Reward	Pain (incongruent)	27	61.4	28	63.6	31	70.5

Note. Freq = Frequency, number of participants; SD = discriminative stimulus; CS = Pavlovian conditioned stimulus. CS1 refers to CS presented with the pain SD; and CS2 to the CS presented with the reward SD. Forty-four participants were included in the analyses. The percentage is calculated based on the total number of participants, per SD-CS configuration per block.

Choice latency

RM ANOVAs conducted for choice latency showed a significant main effect of cue, F (5,43) = 10.12, $p < .001$, η_G^2= = .055, a significant main effect of block, F (2,43) = 27.69, $p < .001$, η_G^2=.056, as well as a significant interaction block × cue, F (10,43) = 2.24, $p = .042$, η_G^2=.019. The results for choice latency are presented in Table III.1.3. Moreover, planned contrasts indicate that participants were initially (block 1) slower in deciding which movement to perform when presented with an incongruent cue compared to all other contexts, all $p < .05$.

Table III.1.3

Mean and standard deviations and t-values of planned comparisons for choice time during the first block of choice trials of the transfer phase

		descriptives		Planned comparisons (*t*)				
	Context	M	SD	2	3	4	5	6
1	no CS	922	550					
2	pain	1116	777	1.35				
3	reward	1206	682	2.16*	-0.59			
4	neutral	1200	746	2.09*	-0.56	0.04		
5	congruent	1036	653	0.88	0.64	-1.22	-1.07	
6	incongruent	1760	1316	4.15**	-3.3*	2.52*	2.6*	-3.92**

Note. CS = Pavlovian conditioned stimulus. Congruent refers to the choice trial in which the painful movement was presented with the CS_p and the reward movement with the CS_r; Incongruent refers to the choice trial in which the painful movement was presented with the CS_r and the reward movement with the CS_p. Forty-four participants were included in the analyses.

*p < 0.05

** p < 0.01

Discussion

The current study investigated whether acquired movement-related fear and avoidance behavior increase in the presence of cues that predict a painful outcome, and decrease in the presence of cues predicting a reward. Participants first performed an instrumental joystick movement task, with arrows indicating the to-be-performed movement (SDs). One movement was painful, whereas another was associated with a reward. Thereafter, participants completed a Pavlovian task, in which three different CSs were associated with either the painful outcome, the rewarding outcome or neither of the two. Subsequently, the Pavlovian cues were integrated in the instrumental joystick movement task. Participants were presented with the movements, which were presented alone or with one of the CSs. Of particular interest to this study was whether these Pavlovian cues modulate the outcome of instrumental responding in terms of pain-related fear, avoidant decision-making behavior and avoidant choice behavior.

Results relating to these questions can be readily summarized. As hypothesized, reported anticipatory pain-related fear for the to-be-performed movement was generally enhanced in the presence of a cue predicting a painful outcome, and in general decreased when accompanied with a cue predicting a rewarding outcome. Regarding avoidant decision-making, participants were overall not willing to perform a painful movement, unless it was accompanied with a cue associated with the reward. However, participants were almost always willing to perform the reward movement, except when a cue associated with pain was presented, indicating that participants show more oscillatory behavior when the outcome predicted by the movement and the outcome predicted by the cue are incongruent. Similarly, when given the choice between performing the painful movement and the reward movement in the presence of cues, participants mostly chose to perform the rewarding movement and thus avoid the painful one. Only when incongruent cues were presented—that is, when the reward cue was paired with the painful movement and the pain cue with the reward movement—participants tended to switch more between performing the painful and reward movement.

Although individuals are confronted with different cues in the environment representing different, sometimes competing demands (Boudreaux & Ozer, 2012), the impact of contextual cues has received little to no attention in the context of pain. The current study is one of the first to help closing the gap in literature on the study of cue-controlled "avoidance" behavior. The findings of the present study provide preliminary evidence that Pavlovian cues indeed influence pain-related fear, thereby further extending existing literature that not only instrumental behavior (Cohen-Hatton et al., 2013; Talmi et al., 2008), but also fear responding and decision making behavior (Balleine & Ostlund, 2007; Bray et al., 2008; Huys et al., 2011) can be cue-controlled. We not only explored the possible detrimental effects of aversive and appetitive cues on responding to aversive movements, but also

focused on the possible interference or facilitation of environmental cues with appetitive movements (Karoly & Ruehlman, 1996). The results suggest that not only aversive cues are capable of increasing fear of a painful or rewarding movement, but that they also decrease the positive experience of performing a rewarding movement. These findings extend existing literature and show that that cues associated with pain are capable of interfering with pleasurable activities (Gandhi et al., 2013; Notebaert et al., 2011). Taken together, fear responding and avoidant decision making may dynamically depend on the contextual cues representing different goals, rather than stable responses (Crombez et al., 2012; Hasenbring, Hallner, & Rusu, 2009; Hasenbring & Verbunt, 2010; Leeuw, Goossens, et al., 2007; Vlaeyen et al., 2009). Furthermore, the study provides evidence that when there is a mismatch between the outcome predicted by the cue and the outcome predicted by the response, people hesitate more and display more oscillatory behavior (Diederich, 2003; Miller, 1944).

These findings may have some clinical implications, although caution is warranted in generalizing the results to the general or a clinical population. It may be useful to target the motivational context in order to reduce pain-related fear and dysfunctional behavior (Crombez et al., 2012; Van Damme et al., 2008; Vlaeyen & Linton, 2012). More specifically, increasing rewarding activities may also be a factor in inhibiting avoidance behaviors and improving functioning (Gatzounis, Schrooten, Crombez, & Vlaeyen, 2012; Schrooten & Vlaeyen, 2010). Identifying contextual cues affecting pain-related behavior as well as possible underlying mechanisms contributing to differences in behavior warrant further scientific inquiry. An interesting avenue to explore is studying the impact of differences in cue value (Vlaev et al., 2009).

There are several limitations to this study. First, the sample of the current study comprised of healthy participants, mostly students. Therefore, generalizability of the results to a clinical population or clinical reality may be limited. Second, the current study employed a short electrocutaneous stimulus, and lottery tickets. For chronic (musculoskeletal) pain patients however, pain is often present for long periods of time, and the outcome associated with performing a movement is usually more pain than usual. Similarly, although lottery tickets have been shown efficient reinforcers in laboratory situations (Talmi et al., 2009; Verhoeven et al., 2010; Vlaev et al., 2009), real life behavior may be influenced by other rewards. Third, although (pain-related) fear is considered to comprise of three different response systems, being verbal responding, escape/avoidance behavior, and physiological responding (Lang, 1968), the latter was not included in current study. Future research would benefit from incorporating a psychophysiological marker of fear in the experimental design, such as the eye blink startle reflex (Lang & McTeague, 2009; Meulders et al., 2011) and pupil dilatation (Anderson & Yantis, 2012). Lastly, although the procedure is quite similar to Pavlovian-to-Instrumental Transfer (Holmes et al., 2010; Talmi et al., 2008), we focused on the impact of (Pavlovian) cues on responses to signalled painful and rewarding movements, and little on the capacity of these cues to affect free operant responding. Given the possible detrimental impact of avoidance behavior on patients' daily

life and pain experience, future studies would merit from further scrutinizing the impact of cues predicting (increases in) pain and reward on avoidance behavior in a context of pain.

CHAPTER III.2
The impact of environmental cues on pain avoidance: a behavioral study

Abstract

This experiment investigated whether environmental cues predicting pain would decrease pain-related avoidance behavior. For this purpose, forty-two healthy participants first completed an instrumental acquisition phase, performing three different movements with a pneumatic robot arm. One movement was associated with 80% chance of painful stimulation and required the least effort to perform, another movement was associated with 50% chance and required intermediate effort to perform, and yet another movement was associated with no chance of stimulation, but required the most effort to perform. Next, participants could choose which of these movements they performed. Subsequently, participants learned to associate three different Pavlovian cues with the painful outcome, a reward consisting of two lottery tickets, or neither of both. In the test phase, comprising of a free and restricted part, these Pavlovian cues were integrated in the movement task. Contrary to our hypothesis, presenting a pain cue resulted in a relative decrease in avoidance behavior compared to the presentation of no cue, a neutral cue or a reward cue, although the safe option was still selected most often. Possible explanations for our findings are outlined in the discussion.

In preparation as: Claes, N., Crombez, G., Franssen, M., & Vlaeyen, J.W.S. (in preparation). The impact of environmental cues on pain avoidance: a behavioral study.

Introduction

Selecting an appropriate response in the face of change is a fundamental characteristic of human behavior (Cohen-Hatton et al., 2013; Emmons, 1986). More specifically, being capable of identifying an event as threatening, emitting a fearful response, and consequently avoiding it is considered adaptive, and in some cases could mean the difference between life or death. For example, individuals will not put their hand on a hot cooking plate. However, these avoidant responses may become maladaptive when used excessively, or in the absence of real threat. Maladaptive avoidance is considered a central characteristic in many mental disorders (Barlow, 2002; Krypotos, Effting, et al., 2015). Similarly, contemporary cognitive-behavioral models of chronic pain posit that misconceptions about painful experiences may give rise to fear and avoidance, which may lead to disuse and disability, severely affecting patients' lives (Vlaeyen & Linton, 2000; Vlaeyen & Linton, 2012). For example, a patient experiencing chronic pain may refrain from valued activities, out of fear that doing so will exacerbate the pain that is already present. In the past, theories of avoidance learning often proposed that fear—or more specifically, the reduction thereof—was primarily responsible for reinforcing avoidance behavior (e.g., Mowrer, 1951). Often, avoidance was described as the behavioral component of fear—next to a verbal (e.g., self-reports) and a physiological component (e.g., skin conductance) of fear—and was considered to covary with fear (Lang, 1968). However, the necessity of fear (reduction) for avoidance behavior has been challenged, and it is now posited that fear and avoidance might act or be affected independently (Beckers et al., 2013; Krypotos, Effting, et al., 2015; Rachman & Hogdson, 1974; Volders et al., 2015). In the field of experimental pain research, Claes and colleagues (Claes, Crombez, & Vlaeyen, 2015; Claes et al., 2014) have demonstrated that a concurrent reward did not alter pain-related fear, but decreased avoidant behavior.

Adaptation to changing environments, is also facilitated by environmental cues that signal certain outcomes, or the absence thereof (Brackbill & Overmier, 1979; Doya, 2008). As such, cues can guide *goal-directed* behavior, but not necessarily in an adaptive way (Holmes et al., 2010). This modulation of instrumental responding by environmental, Pavlovian cues is termed Pavlovian-to-Instrumental transfer (PIT; e.g., Estes, 1943). Two types of PIT can be differentiated. General PIT occurs when Pavlovian cues increase the rate of instrumental responding, even though they have never been associated with a similar outcome as the instrumental response. However, Pavlovian cues can also selectively increase the rate of responding for the instrumental response associated with that particular outcome, which is termed selective PIT. PIT has mainly been studied considering appetitive responding in non-human animals, and only recently in humans (Cohen-Hatton et al., 2013; Dickinson & Balleine, 1994; Holmes et al., 2010; Talmi et al., 2008). In contrast, the modulation of instrumental avoidance by Pavlovian stimuli has received much less attention. Only recently it was demonstrated that when a cue signaling a specific aversive outcome whose omission negatively reinforced the instrumental response, instrumental (avoidance) responding was selectively increased (Lewis et al.,

2013). These authors also observed a general PIT effect, with cues predicting a dissimilar yet aversive outcome increasing overall instrumental behavior. Given the potential detrimental consequences of pain avoidance, it might be fruitful to further explore the impact of environmental cues on avoidance behavior. In the field of chronic pain research, there have been calls to further explore the impact of context and motivation on pain-related behavior, to improve our understanding of the mechanisms underlying the development, maintenance, and exacerbation of chronic pain problems (Crombez et al., 2012; Vlaeyen et al., 2009). In the current experiment, we therefore focus specifically on the impact of environmental cues on the avoidance of painful movements. Participants learned to associate different Pavlovian cues with either an aversive outcome, an appetitive outcome—that is, a painful electrocutaneous stimulus or lottery tickets—or neither of both. These Pavlovian cues were then integrated in an instrumental movement task, in which participants could choose to perform movements that were either followed by a painful stimulus in 80% of the trials, in 50% of the trials, or was never followed by a painful stimulus (safe movement). We expected that the Pavlovian cue predicting a similar, aversive outcome would increase avoidance behavior, that is, selecting the safe movement more often, as compared to a neutral Pavlovian cue and a Pavlovian cue predicting an appetitive outcome. Similarly, we expected that response latencies would be increased when a Pavlovian cue would be presented compared to when a cue was absent, and that the presentation of a Pavlovian cue predicting pain would further increase response latency as compared to a neutral or reward Pavlovian cue. Furthermore, in line with Puca, Rinkenauer, and Breidenstein (2006), we expected that when avoidance would no longer be possible, participants would initially exert more force to avoid the painful movement when the presented Pavlovian cue predicting pain, as compared to when it predicted reward, nothing or was absent.

Methods

Participants

Forty-six healthy Dutch-speaking volunteers—11 males—aged between 18 and 36 years (Mean age: 23.28 ± 3.84 years) participated in the study. Volunteers were recruited via the online recruitment system of the Faculty of Psychology and Educational Sciences of the KU Leuven and flyers distributed on campus and social media. All participants received a financial remuneration of € 15. Exclusion criteria based on self-report were: cardiovascular diseases, lung diseases, neurological diseases (e.g., epilepsy), other serious medical conditions, not being able to freely move the arms, hands and/or shoulders, chronic pain, acute pain or discomfort located at the wrist/hand/shoulder or related body regions, being asked to avoid stressful situations by a general practitioner, presence of electronic medical devices (e.g., pace-maker), pregnancy, use of recreational drugs or medication affecting the intestines or central nervous system, recovering from severe trauma or surgery, or hearing problems and impaired vision that is not corrected (including color blindness). Some task-related exclusion criteria were formulated as well: unsuccessful learning of the contingencies in either

of the acquisition phases—defined as incorrectly answering the contingency check four times—or indicating that both pain-avoidance and reward-seeking were unimportant. The Social and Societal Ethics Committee (SMEC) of the KU Leuven (Belgium) approved the study protocol (reg. no. G-2014 12 117). All participants provided their written informed consent.

One participant indicated that both pain-avoidance and earning tickets were unimportant. For 3 participants, there was a technical error, resulting in incomplete data. These 4 participants were excluded from further analyses. The final sample size is 42—9 male—with a mean age of 22.95 ± 3.47 years.

Apparatus and Software

The experiment was compiled in Microsoft ® Visual Studio, mainly programmed in C/C++, using OpenGL and HM API; and run on an Windows 7 Professional (64 bit) computer (Dell OptiPlex 9020, Dell, Round Rock, TX) with 2 GB Random-access memory (RAM) with an Intel Core i7-4770 processor (Intel, Santa Clara, CA) at 3.4 GHz and an AMD Radeon™ R7 250 graphics card (Advanced Micro Devices, Sunnyvale, CA) with 4 GB of video RAM. The experiment was displayed on a 46-inch Philips TV, model 36PFL3208K/12. Participants could select their answers with a Targus numerical keyboard.

Stimuli

Painful, electrocutaneous stimuli of 2-ms in duration (square waveform) delivered by an Isolated Bipolar Current Stimulator (DS7A; Digitimer ltd, Welwyn Garden City, England) served as the pain outcome. Participants received these stimuli via two surface electrodes (V91-01, Ø 8 mm, Coulbourn Instruments, Whitehall, PA, USA) filled with K-Y gel (Johnson & Johnson, New Brunswick, NJ) attached to the upper right arm at the height of the elbow. The level of stimulus intensity was determined during an individual calibration procedure (see Preparation phase). Lottery tickets—represented by a yellow star on screen—served as the reward outcome. One lottery ticket corresponded with one chance to win a self-selected lottery prize worth approximately € 100 (Claes, Crombez, & Vlaeyen, 2015).

Experimental tasks

The procedure used followed a structure similar to studies on Pavlovian-to-Instrumental transfer (Holmes et al., 2010; Lewis et al., 2013).

In a first, *experimental movement task,* participants executed arm extensions with their right arm using a pneumatic robot arm called the Haptic Master (MOOG Inc., East Aurora, New York, USA), which is a three-degrees of freedom, force-controlled haptic interface. The experimental movement environment allowed movement along the horizontal movement plane (x- & y-axis), whereas movement along the z-axis was restricted (see Fig. III.2.1). The starting point—a red cube of 3.5 by 3.5 cm—was fixed at the bottom left of the movement environment. Similarly, the end point—a red gate of 11.5 cm—was fixed at the top left of the movement environment. In the middle of the movement environment, three red gates of equal width and height represented three different movement paths (left, middle, right). The three movement paths corresponded with 80% chance of painful stimulation, 50% chance of receiving a painful stimulus, and safety, respectively (similar to (Meulders, Franssen, Fonteyne, & Vlaeyen, 2016). Additionally, the Haptic Master exerted 5 N force, making performing movements deviating from the left path more difficult, thus creating a trade-off between effort and pain.

In the Pavlovian learning task, three different neutral cues served as conditioned stimuli (CSs). The cues were a Fire flower, a Blooper, and a Super Mushroom icon (Super Mario Bros, Nintendo ®, Kyoto, Japan). One cue was associated with the pain outcome (Pain CS); another cue was associated with the reward outcome (reward CS); whereas the last cue was associated with neither of both (Neutral CS). Cue-outcome associations were counterbalanced between participants. In the test phase, CSs were integrated in the instrumental movement task.

Measures

Self-reported measures

Rating electrocutaneous stimulus. During calibration, participants rated the painfulness ("pain intensity") of the electrocutaneous stimulus on an 11-point Likert scale ranging from 0 (no pain) to 10 (worst pain imaginable), and on a verbal rating scale reading "Light – medium – serious – enormous". Pain unpleasantness and pain tolerance were equally assessed on an 11-point Likert scale ranging from 0 (not at all) to 10 (very much).

Rating lottery prize and lottery tickets. Upon selection of a lottery prize, participants assessed the difficulty to select a prize, their interest in winning the prize, the value of the prize, how much effort they were willing to exert to win the prize on an 11-point Likert scale ranging from 0 (not at all) to 10 (very much). Participants also estimated their chance of winning the lottery (in

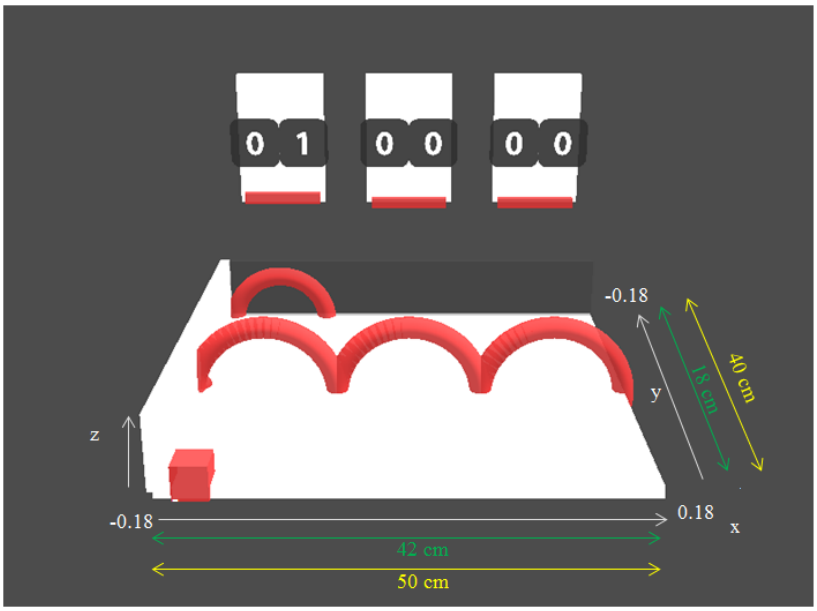

Figure III.2.1. Overview of the experimental environment. Movement is allowed along the x-, y-, and z-axis, as indicated by the white surface. White arrows indicate the Haptically defined movement positions. The green arrows indicate the visual distance on screen. The yellow arrows indicate. the maximal movement distance. A red cube of 3.5 cm x 3.5 cm at the bottom of the screen indicates the start position. The three red gates in the middle represent the three possible movement paths: the left gate is associated with a 80% chance of receiving a painful stimulus; the middle gate is associated with a 50% chance of receiving a painful stimulus; the right gate is associated with safety. A red gate at the top left of the screen indicates the end of a movement. Counter bars indicate the number of movements (to be) made.

percentages). Additionally, the value and pleasantness of the tickets were rated on an 11-point Likert scale ranging from 0 (not at all) to 10 (very much). The value of the tickets were also assessed using a verbal rating scale with the following labels: “light – medium – serious – enormous”.

Goal measures. Before the experimental task started, participants reported the goals they held for the experiment. First, they could sum up their specific goals for this experiment in response to an open question. Next, they ranked each of the following goals according to their importance from 1 to 4: “successfully completing the experiment”, “avoiding the painful stimulus”, “learn the associations as well as possible”, and “earn as much tickets as possible”. Participants also rated each goal’s importance on a scale from 0 (not important at all) to 10 (very important). Additionally, participants were asked to indicate which of the following goals was most important: “reward-seeking”, “pain-avoidance”, “both equally important”, or “both equally unimportant”.

Pain-related fear. After successfully learning the contingencies in the instrumental movement task, participants indicated how afraid they were of a specific movement path (lit-up on screen) on an 11-point Likert scale ranging from 0 (not at all) to 10 (very afraid). Similarly, after having successfully learned the cue-outcome associations in the Pavlovian learning procedure, participants indicated how afraid they were of each of the Pavlovian cues using the same Likert scale.

Questionnaires. Upon completion of the experiment, participants filled in sociodemographic information and the Dutch version of the BIS/BAS scales (Franken, Muris, & Rassin, 2005) online for descriptive purposes.

Behavioral measures

Maximal movement distance. For each movement trial, the total trajectory of the movement was mapped from movement-onset until completion of the movement. Maximal movement distance refers to the point on this trajectory furthest away from the outer left wall of the movement field on the x-axis (corresponding with a value of -0.18). Maximum movement distance ranges from -0.18 to 0.18 (see Fig.III.2.1), with higher values indicating more avoidant behavior.

Movement choice. On each movement trial, we recorded which movement path was chosen by the participant. Moving along the left path, associated with 80% of painful stimulation was coded as a '1', moving along the middle path associated with 50% of painful stimulation was coded as '2', and the right, non-painful path, as '3'. Movement choice is a measure of avoidance behavior, with a higher number indicating more avoidant behavior.

Response latency. Time of movement-onset was recorded on every movement trial, and operationalized as the time in seconds between the start signal (auditory) and leaving the start region (red cube; 10% of the total y-axis area).

Response duration. Similarly, time of movement completion was recorded, and defined as the time in seconds between leaving the start region and reaching the end point (red gate), as announced by an auditory stimulus.

Force. During instructed test trials, the force in Newton participants exert in order to avoid performing movements along the left path was recorded.

Procedure

The study was conducted in a sound-attenuated experiment room located at the Faculty of Psychology and Educational Sciences, KU Leuven (Belgium). An experimental session lasted about 90 minutes.

Preparation phase

Upon arrival in the laboratory, participants received oral and written information on the purpose and course of the study, and were provided with the opportunity to ask for clarification before giving informed consent. The experimenter (female; A.D.K; N.C.) informed the participants that during the experiment, they would be exposed to painful electrocutaneous stimuli, but that the level of stimulus intensity would be individually determined. The intensity of stimulation was increased until a stimulus that was painful and required some effort to tolerate was identified. Participants could indicate when they no longer wished to increase stimulus intensity, and rated each stimulus' painfulness, unpleasantness and tolerance. The experimenter asked participants whether s/he agreed upon repeatedly receiving stimuli of maximally the selected intensity before continuing the experiment. Subsequently, the experimenter explained that lottery tickets could be earned during the experiment, with which they could win a prize of their choice worth approximately € 100. The experimenter requested participants to select one prize out of a list of 36 possible prizes, and fill in the questions related to their prize. Next, the experimenter stated that the more tickets participants earned, the more chance they had of winning their prize. Next, participants assessed ticket value and ticket pleasantness. Lastly, the experimenter asked the participants to complete the goal-related questions.

Practice phase

Participants were enabled to practice the use of the numeric keyboard to answer the questions and performing movements with the Haptic Master before advancing to the first experimental task. First, the experimenter informed the participant that during the experimental task, the participant would be requested to answer questions using the numeric keyboard. To get acquainted with the use of the keyboard, the experimenter showed the different question types on screen as they would appear during the task, and instructed the participant to select an answer option (e.g., "select the middle gate"; "give a score of 10"). Participants could practice until they felt confident in using the numeric keyboard. Next, the experimenter explained that participants would make arm extension movements with the Haptic Master, and now had the opportunity to practice these movements, without receiving electrocutaneous stimuli or lottery tickets. The experimenter demonstrated a movement through each gate, and consequently asked the participant to move through each gate at least twice. Again, participants were enabled to continue practicing until they felt confident in handling the Haptic Master. Participants were instructed to make a movement as soon as they heard an auditory start signal administrated via headphones, through one of the gates of their choice, until they reached the end gate. Successful completion of a movement was announced using an auditory signal. Upon movement completion, the Haptic Master automatically moved back to the start position. A new trial started after 100 ms. Some examples of actual performed movements are presented in Figure III.2.2.

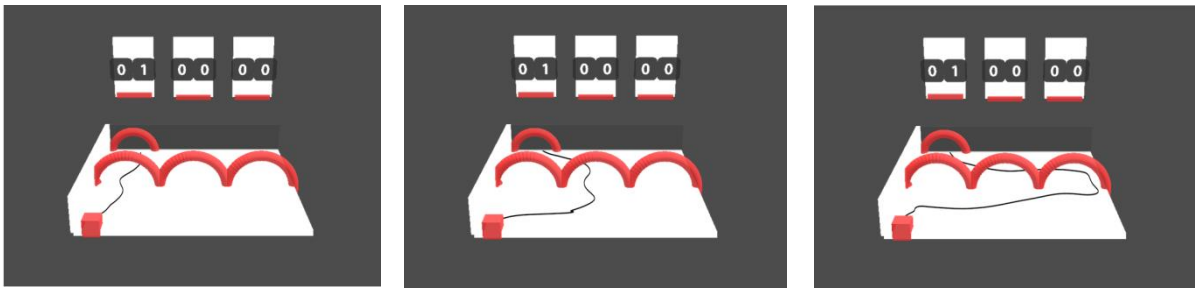

Figure III.2.2. Movement examples. Examples of movements performed by a participant for the left, middle, and right path, respectively.

Instrumental acquisition phase

In this phase, participants were instructed to perform movements through one of the three gates as soon as they heard the start signal, and were informed that movements would now be associated with either (a) 80% of receiving a painful stimulus, (b) 50% of receiving a painful stimulus, or (c) no painful stimulation, and it was up to them to learn which movement path was associated with each outcome. It was also mentioned that some movements would require more effort than others to perform. No lottery tickets could be earned during this phase. Participants could choose the order in which they performed the movements, but completed 12 arm extensions per movement path (36 movements in total). For each participant, a movement straight ahead (left gate) was associated with 80% of painful stimulation, but it was also the easiest to perform; the middle gate was associated 50% of painful stimulation and was somewhat harder to perform; and lastly the right gate was never followed by a painful stimulation but was at the same time the hardest to perform. Painful stimuli were administrated upon completion of the movement. Upon completion of this first block, a contingency check was administered. Participants were asked to indicate which movement path was associated with 80%, 50%, and no painful stimulation by selecting the corresponding gate using the numeric keyboard. If participants were unsuccessful in learning the contingencies, they completed another block of 36 movements and were again presented with the contingency check questions. Participants could complete up to three additional blocks. If the last contingency check was answered incorrectly, the experiment was stopped for these participants. If participants answered the questions correctly, they assessed pain-related fear for each of the movement paths. The course of a trial was similar as in the practice phase.

Baseline free operant phase

When the movement-pain outcome contingencies were successfully learned, participants were instructed to again perform arm extensions, but that they now could choose which movement they made. As such, they no longer were requested to move through each gate. The instructions stressed that the contingencies from the previous phase still held. Participants performed 12 movements in

total. We a priori determined a reinforcement plan for each of the movement paths that corresponded with 80%, 50%, and no reinforcement, respectively. Participants' response latency, response duration, maximal movement distance, and movement choice were registered for each trial.

Pavlovian acquisition phase

Next, participants were asked to complete a second learning task, in which they would be presented with different cues (CSs), which either predicted the painful stimulus, the reward outcome, or neither of both. The aim of the task was to learn the cue-outcome contingencies. A trial started with a 100 ms presentation of a fixation cross, followed by the presentation of the CS at the top of the screen, accompanied by the outcome after 100 ms. Participants were presented with 1 block of 4 presentations of each CS. The pain CS was accompanied by the pain outcome and the reward CS by the reward outcome in 75% of the trials; whereas the neutral CS was never reinforced. Cue-outcome contingencies were counterbalanced between participants. As in the instrumental acquisition phase, a contingency check was administered. Participants were asked to indicate what each specific cue predicted using the numeric keyboard: (a) painful stimulation, (b) lottery tickets, and (c) nothing. If participants answered the questions incorrectly, participants were presented with maximally 3 additional blocks, otherwise the experiment was stopped. If participants successfully learned the cue-outcome contingencies, they rated pain-related fear for each of the cues.

Free Pavlovian-Instrumental test phase

Next, participants were informed that in the ensuing phase, the cues would be integrated in the movement task. Instructions stated that participants again were asked to perform arm extensions of their choice, as soon as the start signal sounded, and stressed that the *movement - pain outcome* associations still held. In total, participants were presented with 4 blocks of 3 pain CS, 3 reward CS, 3 neutral CS, and 3 no CS trials (48 trials in total). We a priori determined a reinforcement plan for each of the movement paths per CS type that corresponded with 80%, 50%, and no reinforcement, respectively. We registered response latency, response duration, total movement distance, and movement choice for each trial.

Restricted Pavlovian-Instrumental test phase

Immediately following the free Pavlovian-Instrumental test phase, the restricted test phase ensued. An invisible wall was placed between the left and middle gate in the movement environment, preventing participants to avoid the left (painful) movement path, in order to measure the exerted force (effort) to avoid when avoidance was no longer possible. Participants completed 12 trials in total, 3 blocks of 1 trial per CS type (Pain CS/reward CS/neutral CS/no CS). All movements were reinforced.

Debriefing

Upon completion of the experimental task, the experimenter requested participants to fill in the questionnaires online. The course of the lottery was explained, as was the aim of the experiment.

Participants could leave their contact information so they could be contacted if they won the lottery, and indicate whether they wished to be informed about the results of the study. The computer randomly selected one of the participants as the winner of the lottery.

Results

Data-analytic strategy

To examine the effect of CS type on the maximum movement distance, response latency, and movement duration, we conducted separate 4 × 4 (CS type [None/Pain/Reward/Neutral] × block [1/2/3/4]) repeated measures analyses of variance (ANOVA) during the free test phase. For the variable movement choice, we conducted a Chi Square Test to examine the overall effect of CS type. For force during the restricted test phase, a repeated measures ANOVA with CS type (None/Pain /Reward/Neutral) and block (1/2/3) as within-subject factors was calculated. Follow-up contrasts are reported when appropriate. All analyses were conducted using SPSS 22.0 (SPSS Inc., Chicago, IL), and Microsoft® Office Excel 2010. Alpha levels were set at .05. When Mauchly's test of sphericity was violated, Greenhouse Geisser corrections are reported. Where appropriate, generalized eta squared (η_G^2) is reported as a measure of effect size (Bakeman, 2005; Lakens, 2013; Olejnik & Algina, 2003).

Descriptive statistics

Pain stimulus descriptives

The average stimulus intensity was 26 mA (± 1.35 mA). On average, participants indicated the selected stimulus was painful, and gave a score of 8.40 (± 0.63) on the painfulness scale. The average scores for unpleasantness and tolerability of the stimulus were 8.26 (± 1.01) and 7.93 (± 0.97), respectively. Most participants (52.4%) chose to enter the lottery to win an additional € 100 or gift vouchers for different companies (23.9%). The value of the selected prize was rated 7.05 (± 2.65). Participants scored the difficulty to select a prize 4.52 (± 2.83), and the interest in winning the lottery prize 7.86 (± 2.4). The amount of effort they were willing to exert was rated 7.71 (± 1.83). Participants indicated that the lottery tickets were valuable, and on average scored ticket value 7.21 (± 2.35). Mean pleasantness of the ticket was 8.24 (± 1.95).

Goal measures

The importance of avoiding pain during the experiment was rated on average 6.31 (± 2.34). The importance of earning lottery tickets during the experiment was rated 6.81 (± 2.66). These ratings did not significantly differ, $t(41) = -1.174$, $p = .247$. Sixteen participants indicated that both goals were equally important; 17 indicated earning lottery tickets was the most important goal; 6 preferred to avoid pain over earning lottery tickets.

Questionnaires

Participants had an average score of 23.55 (± 3.81) on the BIS scale, 11.86 (± 2.08) on the BAS drive scale, 11.07 (± 2.04) on the BAS fun seeking scale, and 17.48 (± 2.03) on the BAS reward responsiveness scale. These scores are similar to average scores obtained in a sample Dutch-speaking students (Smits & Boeck, 2006) and norm scores from a general population (Jorm et al., 1998).

Baseline behavior

The maximum movement distance ranged from -0.123 to .144, with a mean maximum movement distance of .062 (± 0.069). Participants most often chose to take the safe path (66%), whereas the paths corresponding with 80% and 50% chance of pain were only selected in 17% of the trials each. The mean response latency was 418 (± 141) milliseconds. The mean movement duration was 2580 (± 825) milliseconds. Baseline behavior did not significantly differ from test trials where no CS was presented, *p*s > .084.

Manipulation check

The majority of participants (30) successfully learned the contingencies in the instrumental acquisition phase after 1 block; 8 participants needed one additional block; 4 participants needed 2 additional blocks. Similarly, for the Pavlovian acquisition phase, the majority of participants (34) learned the contingencies after completing 1 block; 5 participants needed 1 additional block, 2 participants needed 2 additional blocks, and 1 participant needed 3 additional blocks.

In the instrumental acquisition phase, participants reported to be more afraid to perform a movement associated with the left—most painful—path (6.43 ± 2.39) than a movement associated with the middle path (5.36 ± 1.82), $t(41) = 4.26$, $p < .001$. In turn, they reported to be more of afraid of the latter movement than the movement associated with the right—safe—path (0.57 ± 1.25), $t(41) = 13.48$, $p < .001$. In the Pavlovian phase, participants reported to be more afraid of the pain cue (7.24 ± 1.9) than the neutral cue (0.62 ± 1.08), $t(41) = 19.83$, $p < .001$. There was no difference in fear ratings for the neutral cue and the reward cue (0.69 ± 1.3), $t(41) < 1$, $p = .607$. Interestingly, participants were more afraid of the pain cue than the movement associated with the left path, $t(41) = -2.52$, $p = .016$.

Behavioral measures

Maximum movement distance

There was a significant main effect of block, as well as CS type, $F(3, 123) = 2.98$, $p = .047$, $\eta_G^2 = .0106$ and $F(3,123) = 7.9$, $p = .001$, $\eta_G^2 = .0639$, respectively. There was however no Block × CS type interaction, $F < 1$ (see Fig. III.2.3). Upon closer inspection, it seems that at block 1, there was no difference in maximum movement distance when there was no cue presented compared to the presentation of a cue, ps > .105. However, participants seemed to avoid less when presented with a pain cue compared to the neutral cue and the reward cue, $t(41) = -3.816$, $p < .001$ and $t(41) = -4.221$, $p < .001$, respectively. These differences were still present at block 4, pain cue vs. neutral cue: $t(41) = -2.747$, $p = .009$; pain cue vs. reward cue: $t(41) = -.471$, $p = .018$.

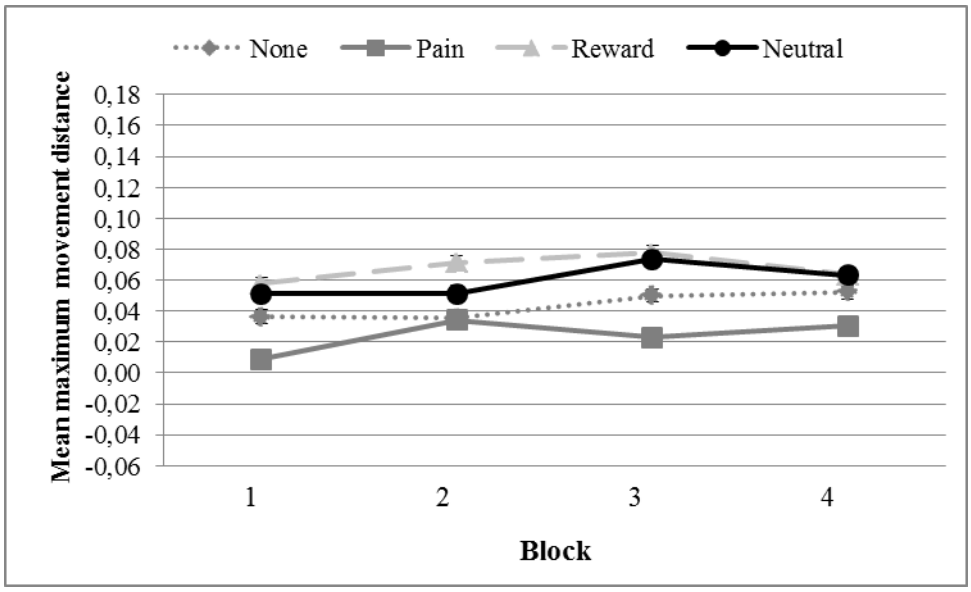

Figure III.2.3. Mean maximum movement distance during the free test phase.

Movement choice

The expected and observed frequencies of the choices for each individual movement path during the test phase are described in Table III.2.1. The analysis showed that there was a significant association between CS type presented and the movement choice, $\chi^2(6) = 145.85$, $p < .001$. As can be seen in Table 1, there was a larger than expected number of times participants chose the paths associated with 80% and 50% chance of pain when presented with a pain cue. It should however be noted that overall, participants chose the safe path in at least 42% of the trials when a pain cue was presented (as compared to 59-69% when presented with other cues).

Table III.2.1

Observed and expected frequencies of movement choices per CS type in the test phase

CS type		Movement path		
		1	2	3
None	Observed	143	62	299
	Expected	*109.3*	*95.8*	*299*
Pain	Observed	120	173	211
	Expected	*109.3*	*95.8*	*299*
Reward	Observed	77	77	350
	Expected	*109.3*	*95.8*	*299*
Neutral	Observed	97	71	336
	Expected	*109.3*	*95.8*	*299*

Response latency

The analyses yielded a main effect of block, $F(3, 123) = 14.81$, $p < .001$, $\eta_G^2 = .1117$, and a main effect of CS type, $F(3,123) = 3.2$, $p = .035$, $\eta_G^2 = .0111$ (see Table III.2.2). The CS type × block interaction was not significant, $F(9,369) = 2.06$, $p = .105$, $\eta_G^2 = .0162$. Planned contrasts revealed that participants initiated the movement faster when there was no cue presented compared to when they were presented with a pain cue, $F(1,41) = 6.44$, $p = .015$. There was no difference in response latency between the pain cue and the reward cue, nor between the reward cue and the neutral cue, *p*s > .129.

Response duration

The results showed that participants became gradually faster over time, main effect of block, $F(3, 123) = 10.336$, $p < .001$, $\eta_G^2 = .0528$. There was however no effect of CS type, $F(3, 123) = 1.41$, $p = .249$, $\eta_G^2 = .0062$, nor an interaction between CS type and block, $F(9, 369) = 1.3$, $p = .272$, $\eta_G^2 = .0118$ (see Table III.2.2).

Force

Force exerted during the restricted test phase: the results only yielded a significant main effect of block, $F(2, 82) = 51.91$, $p < .001$, $\eta_G^2 = 0.182$, indicating that participants exerted less force over time. Both the main effect of CS type as the interaction were not significant, *p*s > .974.

Table III.2.2

Mean and standard devation for response latency and response duration in milliseconds per block and per CS type

Variable	CS type	Block			
		1	2	3	4
		M(SD)	*M(SD)*	*M(SD)*	*M(SD)*
Response latency	None	472(187)	434(121)	415(128)	412(126)
	Pain	598(371)	438(131)	447(155)	408(111)
	Reward	555(369)	426(129)	423(121)	403(102)
	Neutral	597(354)	453(151)	427(133)	426(115)
Response duration	None	2655(936)	2446(932)	2335(701)	2328(7360)
	Pain	2601(861)	2373(739)	2290(664)	2453(1302)
	Reward	2777(786)	2624(659)	2436(677)	2255(555)
	Neutral	2817(933)	2585(900)	2456(643)	2309(587)

Discussion

The current study investigated the impact of environmental cues on pain-motivated avoidance behavior. More specifically, we incorporated Pavlovian cues predicting either pain, reward, or neither of both in an instrumental avoidance task to uncover whether cues predicting pain would increase pain avoidance. Contrary to our hypothesis however, this study demonstrated that a Pavlovian cue predicting a painful outcome resulted in a relative decrease in avoidance behavior compared to the presentation of no cue or a neutral cue, as was evident in the maximal movement distance, as well as the more frequent selection of movements associated with 80% and 50% stimulation, respectively. However, it should be noted that the safe movement (=complete avoidance) was still selected in 42% of the trials. These findings are surprising, first because participants were explicitly instructed to move as they pleased and to ignore the Pavlovian cues, and second because they go against the Pavlovian-to-

Instrumental transfer effects described in literature (Holmes et al., 2010; Nadler, Delgado, & Delamater, 2011; Van Meurs et al., 2014). Although these results may seem contra-intuitive, there may be a viable explanation. In the remainder of the paper, we will present possible causes that might explain our findings.

First of all, it may well be that the results are driven by a particular subgroup of individuals. One characteristic especially relevant in studying PIT is motivation, as is evident from motivational dual-process theoretical accounts (Balleine & Ostlund, 2007; Mowrer, 1947, 1951) stating that Pavlovian cues may interfere with goal-directed action (De Wit & Dickinson, 2009; Huys et al., 2011). In our experiment, participants were firstly instructed to perform the movements as quickly as possible. As is often the case in experimental research, participants' main goal was to complete the task as is required. The action best matching this goal, is to perform movements straight ahead, which were also the movements associated with the highest chance of pain. Moreover, we also asked participants which goal they deemed most important during the experiment, either pain-avoidance, reward-seeking, or both equally important. Based on these goals, the same action may be considered in light of their goal: a painful movement that is also the fastest and therefore also the less tiresome movement matches the goal of the reward-seeking individual who wishes to complete the task and earn 'points', whereas it deviates from the pain-avoidance goal. To explore the effects of general motivation, we looked at the patterns emerging in our different groups based on their prioritized goal. The patterns were as follows: pain-avoiders (N'=9) showed a significant general increase in avoidance behavior if a cue was presented compared to when a cue was absent, and was even higher when the cue signaled pain. Reward-seekers (N'=17) and participants who found both goals equally important (N'=16) however, showed a significant decrease in avoidance behavior—and more frequent performance of the movement associated with 80% chance of pain—when the Pavlovian cue signaled pain, and an increase in avoidance behavior when the cue signaled reward or neither pain nor reward compared to the absence of a Pavlovian stimulus. This difference between individuals seems to suggest that Pavlovian cues predicting pain indeed contribute to increased avoidance, but only if the individual is primarily motivated to avoid pain. In other words: the expected pattern of responding was found in the pain-avoiders group, but not in the other groups. Future research would benefit to incorporate a priori motivation when studying the impact of environmental cues on motivated (avoidance) behavior, either by recruiting according to motivation, or by manipulation of motivation, possibly via verbal instructions, to increase power. In a context of chronic pain, the latter might be especially interesting, because it might provide insights as to how clinicians' instructions to patients may potentially impact patients choices. It should be noted that in the pain-avoiders group, the increase in avoidance behavior was non-specific, since both presenting a neutral and a reward cue increased avoidant responding as well. This differentiation between presence and absence of a Pavlovian cue was also evident in the response latency data for the group as a whole: participants were

slower in initiating a movement when a cue was presented compared to when no cue was presented, indicating that participants integrated the prospects of pain from the instrumental responses as well as engendered by the cues, possibly resulting in a summation.

Second, task characteristics may have contributed to the pattern of responding found in the group as a whole, as was also observed in the reward-seeking and equally important-group. Our experiment fundamentally differs from classic PIT (avoidance) experiments in humans on which we based our hypotheses (e.g., Lewis et al., 2013; Nadler et al., 2011; Watson, Wiers, Hommel, & De Wit, 2014). To the best of our knowledge, our study is one the first to explore the effects of environmental cues in a context where the negative outcome—in our case, pain—can both be actively approached as well as actively avoided. Studies investigating PIT-effects in avoidance, have mostly used designs in which participants had two available response options, both of which resulted in averting/preventing a different negative event (e.g., Lewis et al., 2013; Nadler et al., 2011). Furthermore, the negative outcomes were reinforcers specific to the task at hand, rather than primary or secondary reinforcers as used here. Our study more closely resembles the study of Van Meurs and colleagues (2014), who studied the generalization of (maladaptive) avoidance behavior. These authors gave participants two response options: either an 'avoidant' response which resulted in the avoidance of painful stimulation but also in the loss of crops (relevant for the task) or harvesting crops, which resulted in the administration of a painful stimulus. As such, both response options had a negative and a positive consequence, which may be considered a double approach-avoidance (conflict) situation (Lewin, 1935; Miller, 1944). In our study, this trade-off between positive and negative consequences was present as well, but may have not been as strong. More specifically, we had a trade-off between the chance of receiving pain and the effort required to perform the movement: the higher the chance of pain—related to the goal to avoid pain—the less effort was needed to perform the movement—related to the (instructed) goal to complete the movements as fast as possible—, and vice versa. However, if participants exerted more effort, safe movements could be performed as fast as painful movements, which may have created an imbalance in the trade-off, which in turn may have affected participants' choices. Future studies may want to increase difficulty of movement, or stress accuracy of movement instead of speed of movement to overcome this limitation.

Third, and related to the previous point, is that the pattern of responding observed in our study may reflect a PIT effect, although in a different way than we expected. It is possible to interpret the three movement pathways (Responses, R) in our experiment as follows: initially, the first movement path (R1) is associated with a painful outcome (O1). The same is true for the second (middle) pathway (R2), albeit using a different reinforcement rate. The third movement path (R3) however is associated with safety, which from a functional perspective can be viewed as a positive outcome (O2). As such, participants learned 3 associations in the instrumental phase: R1-O1, R2-O1, and R3-O2. In the Pavlovian phase, participants then learned an association between the first cue (S1) and a painful

outcome (O1), a second cue (S2) and a new, positive outcome (O3), and lastly a third cue (S3) with neither of both, which may have been interpreted as safety as well (O2). Our results seem to suggest that the CS functions as a 'reminder' cue to select a certain action, irrespective of the outcome it is associated with. Our results are in line with the finding in appetitive PIT that cues bias responding toward a certain response option, regardless of (the desirability of) the outcome. In the context of food for example, Watson and colleagues (2014) found elevated responses toward food outcomes, although participants were sated. Similar effects have been observed in smoking (Hogarth, 2012; Hogarth & Chase, 2011). We may posit that our research demonstrates that cues bias responding toward a specific action, even if the outcomes are undesirable to begin with, at least in an experimental context. However, such claims cannot be made based on this study alone, and more research is warranted to see whether this hypothesis holds true. At the least, if we frame our experiment as outlined above, we demonstrated that in this experiment, participants responded congruently based on the outcome presented. However, this behavior may have been caused by social desirability, and as such, caution is needed when interpreting the results.

Lastly, another viable explanation for our results stems from an expectancy-based framework (cf. Dickinson & Balleine, 1994). It may very well be that the presentation of a pain cue elicits the expectation of pain, and as a consequence, patients may have reasoned along the lines of "I am receiving pain anyway, so I might as well do the movement that is the fastest/easiest". The fact that our test phase did not took place under extinction, may have allowed participants confirm this (false) belief. We therefore recommend to include at the least nominal extinction in the test phase.

PART IV:

A systematic examination of goal conflict in chronic pain patients

CHAPTER IV.1

The assessment of goal conflict in fibromyalgia: a daily reconstruction method

Abstract

When suffering from chronic pain, attempts to control or avoid pain often compete with other daily activities. This competition between activities is often referred to as "goal conflict". Despite its potential clinical relevance, the presence and effects of goal conflicts in patients with chronic pain remain poorly understood. Therefore, this study systematically mapped the presence and experience of goal conflicts in patients with fibromyalgia compared to healthy controls. Forty patients and 37 controls completed a semi-structured interview in which they first reconstructed the previous day, identified conflicts experienced during that day, and classified each of the conflicting goals in one of nine pre-defined goal categories. Additionally, they assessed how they experienced the previous day and the reported conflicts. Results showed that patients did not experience more goal conflicts than healthy controls, but that they did differ in the type of conflicts experienced. Compared to controls, patients reported more conflicts related to pain, and fewer conflicts involving work-related, social or pleasure-related goals. Moreover, patients experienced conflicts as more aversive and more difficult to resolve than control participants. This study provides more insight in the dynamics of goal conflict and daily life, and indicates that patients perceive conflict as more aversive than controls, and that conflict between pain control (and avoidance) and other valued activities plays a consequential part in patients' lives.

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Introduction

The Fear-Avoidance model of chronic pain (Vlaeyen & Linton, 2000; 2012) essentially describes two possible cognitive-behavioral responses to pain. On the one hand, the individual may appraise pain as nonthreatening, and gradually resume activities. On the other hand, pain may be interpreted as a sign of injury, which in turn may lead to pain-related fear, resulting in avoidance behavior and hypervigilance. When such pattern of avoidance persists, it may bring along depression, social isolation or disability. Although there is evidence validating these behavioral responses (Leeuw, Goossens, et al., 2007; Wertli et al., 2014; Zale et al., 2013), some challenges remain (Crombez et al., 2012).

There is a call for including the broad motivational context into the model, since patients with chronic pain often not only want to avoid or control pain, but may also want to pursue other valued activities, such as going out with friends (Crombez et al., 2012; Vlaeyen et al., 2009). Different relations may exist between these pain avoidance goals and other goals. Avoiding pain may facilitate pursuing other activities (termed "goal facilitation"), but it may also interfere with goals ("goal interference"; Boudreaux & Ozer, 2012; Riediger & Freund, 2004). When the pursuit of one goal undermines the pursuit of another goal, or when several responses/behaviors are incompatible or draw on the same restricted resources such as time, this interference may give rise to goal conflict (Lewin, 1935; Miller, 1944; Riediger & Freund, 2004). The responses described by the Fear-Avoidance model can be reframed in motivational terms: the pattern of misinterpretation may correspond with the prioritization of the goal to control or avoid pain at the cost of other goals, whereas the confrontational response may reflect the prioritization of and engagement in other life goals, despite pain (Crombez et al., 2012; Lauwerier et al., 2012; Van Damme et al., 2008). In general, research has demonstrated that experiencing goal conflict negatively affects people's well-being (Boudreaux & Ozer, 2012; Emmons & King, 1988). In the context of chronic pain, it has been found that pain patients experience more goal frustration as well as more goal conflict than control participants (Karoly et al., 2008). Furthermore, goal conflict has been associated with more pain-related fear (Karoly et al., 2008), and with a greater increase in pain from morning to evening (Hardy et al., 2011). However, the potentially detrimental effects of goal conflict on well-being has not always been replicated (Segerstrom & Solberg Nes, 2006), suggesting that contextual or situational factors may play a role (Gorges, Esdar, & Wild, 2014).

In this paper, we seek to further develop our understanding of goal conflict in the context of chronic pain. First and foremost, we wanted to map the presence and experience of goal conflicts in patients with fibromyalgia compared to healthy controls. More specifically, we (1) examined whether pain patients experience more goal conflict in daily life than do healthy participants; (2) explored whether patients and controls perceive conflict differently, and (3) investigated whether the experience

of pain-related goal conflict was related to core constructs of the Fear-Avoidance model, such as catastrophizing and pain-related fear.

To this purpose, patients with fibromyalgia and matched healthy controls were invited to participate in a semi-structured interview based on the Daily Reconstruction Method (Kahneman et al., 2004) in which we first reconstructed the previous day in keywords. Next, we provided a working definition of goal conflict and participants identified conflicts—matching the definition—experienced during the previous day. Subsequently, participants assessed the experience of maximally three reported conflicts. Then they were asked to classify each of their goals in one of the pre-defined categories. Lastly, participants rated their pain, fatigue, emotions, and general experience of that day. In order to relate the experience of conflict to core constructs of the Fear-Avoidance model, participants completed several questionnaires prior to partaking in the interview.

Methods

Participants

To conduct the current study, the Pain-Attention-Motivation Project 1 (PAM-I-Project; Claes, De Paepe, et al., 2015), consisting of one experimental and two observational studies investigating attentional and motivational processes in the context of pain, was developed. The aim of the experimental study was to investigate the impact of chronic pain on attention towards stimuli entering the space within arm's length of the individual (the so-called peripersonal space). Therefore, participants were presented with dynamic receding or approaching visual stimuli that could be followed by a (vibro)tactile stimulus. Participants were requested to respond as fast and accurately as possible to the occurrence of a tactile stimulus. In the first observational study—described in this paper—participants completed a semi-structured interview to map the experience of goal conflict. The second observational study was explained at the end of the interview, and comprised of an event-sampling procedure in which participants reported the goal conflicts experienced during the day, and filled out an end-of-day questionnaire for 14 consecutive days. The research protocol of the PAM-I-Project is available at http://hdl.handle.net/1854/LU-7032736. The PAM-I-Project was approved by the Medical Ethical Committee of Ghent University Hospital. All participants received reimbursement for their expenses.

Patients with fibromyalgia

Patients with fibromyalgia seeking health care between the ages of 18-65 years were recruited in two ways: (a) From July 2011 - August 2014, posters were placed in the waiting room of the Multidisciplinary Pain Centre of Ghent University Hospital, and medical doctors informed patients about the possibility to participate in research. Eighty-four interested patients with fibromyalgia provided their contact information to be contacted for participation; (b) Since August 2014, all patients are asked to complete online questionnaires at intake. Upon completion of these questionnaires,

participants provide their contact details for research purposes. Fourteen individuals with fibromyalgia left their contact information. The total number of individuals with fibromyalgia registered to be contacted was 98. We contacted 90 of these candidates, of which 50 did not wish to participate. Most common reasons for non-participation were distance to the faculty, time constraints, or aggravation of complaints. The primary inclusion criterion was being diagnosed with fibromyalgia by the pain center. General inclusion criteria were: fluency in the Dutch language, normal or corrected-to-normal eyesight, normal or corrected-to-normal hearing. Participants were excluded if they suffered from neurological problems (e.g., epilepsy). Participants were also requested to report whether they experienced reduced tactile sensitivity on the arms, as this was relevant for the task requirements of the experimental study of the PAM-I-project. In total, 40 patients with fibromyalgia (3 male) participated. Patients were between 29 and 64 years of age (M = 45.8, SD = 9.22). The majority of patients was married (57.5%), or cohabiting (5%). Fifteen (37.5%) patients received higher education. Only 22.5% of patients was employed, 5% was retired, and 7.5% was unemployed. The remaining patients received health insurance (17.5%) or disability (47.5%) benefits. The mean reported duration of patients' pain was 14.5 ± 12.01 years.

Healthy control participants

We recruited control participants matching sex, age and educational level of the fibromyalgia patients. Healthy participants were recruited in several ways to participate in research of the Health Psychology Lab of Ghent University: advertisements in local newspapers or social media, flyers distributed around the university campus and public venues. Hundred and eighty-one candidate individuals expressed their willingness to participate in research and left their contact information. We contacted 55 of these candidates, of which 13 did not wish to participate. Most common reasons for non-participation were suffering from a chronic illness and lack of time. In total, 41 controls participated. Inclusion criteria were the same as those for patients. The exclusion criteria were: suffering from neurological problems (e.g., epilepsy) and insensitivity on the arms. Additionally, control participants were excluded if they suffered from pain of a severe intensity (category II, III or IV) according to the criteria of Von Korff, Ormel, Keefe, and Dworkin (1992), and when they met the criteria for fibromyalgia as defined by Wolfe and colleagues (2010). Three participants suffered from pain of a severe intensity, another met the diagnostic criteria for fibromyalgia. These four participants were all excluded from analyses. The final sample comprised of 37 healthy controls (4 male), with a mean age of 45.92 ± 10.14 years. Most control participants were either married (29.7%) or living together with a partner (16.2%). 40.5% received higher education. The majority of control participants was in paid employment or received education (62.2%), 5.4% was retired, and 27% was unemployed. One participant was in unpaid employment, and another received health insurance benefits.

Control participants did not significantly differ from patient participants in sex, $t(75) < 1$, $p = .619$, age, $t(75) < 1$, $p = .957$, or level of education, $t(75) = -1.31$, $p = .194$. All participants provided informed consent and were informed that participation was voluntary and could be stopped at any point in time, without negative consequences.

Procedure

All participants were invited for an individual appointment at Ghent University, which took approximately 3 hours. Before the individual appointment, participants were asked to complete a sociodemographical information sheet (i.e., age, gender, profession, education level, work status) and several questionnaires. Patients additionally provided information on their pain problem, and completed questionnaires related to pain (for an overview of all questionnaires, see the PAM-I-Protocol). Seventy participants filled in these questionnaires online, 7 participants filled in a paper version.

After having given informed consent, both patients with fibromyalgia and control participants completed questionnaires assessing the extent of pain, severity of symptoms, pain intensity and pain severity. Next, participants completed an experimental task in order to investigate the effects of pain on attention to visual stimuli entering peripersonal space (e.g., De Paepe, Crombez, Spence, & Legrain, 2014). In the current study, the participants completed a semi-structured interview based on the Daily Reconstruction Method (DRM; Kahneman et al., 2004), together with an interviewer (N.C., N.D., E.D.M., J.M; all female). This semi-structured interview was constructed in collaboration with (pain) experts and was extensively piloted prior to the study. All interviewers were extensively trained in using the standardized interview protocol. During the interview, participants first reconstructed their previous day, next reported the number of goal conflicts experienced during that day, categorized the goals involved, and assessed the emotions and overall experience of the conflict(s). Lastly, participants assessed their pain, fatigue, emotions, and general experience of that day. At the end of the interview, the interviewer asked participants to participate in the third study (diary study). Participants were thanked for their participation, and received a contact form with information of the researchers and professional workers. The interview lasted about 60-90 minutes per participant.

Materials and measures

Sociodemographic information

For descriptive purposes, all participants provided information on sex, age, education, employment, and marital status. Patients also provided information on the duration and treatment of their pain problem.

Diagnostic Criteria for fibromyalgia

Participants completed the Dutch version of the Diagnostic Criteria for fibromyalgia (Geenen & Jacobs, 2010; Wolfe et al., 2010) before the start of the experimental study. In this questionnaire, a widespread pain index (WPI) is calculated by counting the number of reported painful body regions. Respondents can indicate the number of painful locations. The WPI is a number between 0 and 19. Second, respondents report on their cognitive symptoms (difficulties thinking and concentrating), unrefreshed sleep, fatigue, and number of extra—mostly somatic—symptoms (e.g., head ache, fever, tinnitus) by using a scale from 0-3. A 0 indicates that the symptom is absent or there are no symptoms; a 1 indicates a mild or periodical presence of the symptom or little symptoms, a 2 indicates that there is a considerable number of symptoms, and a 3 indicates a lot or serious symptoms. The summation of these 4 items results in a Symptom Score (SS) ranging from 0 to 12. To meet the criteria of fibromyalgia, 1) pain and other symptoms should be present for at least 3 months, 2) there should be no other condition that may explain the experienced pain, and 3) the WPI score should be equal to or higher than 7, and the SS equal or higher than 5, or the WPI situates in between 3 and 6 and the SS score is equal to or higher than 9.

Pain Severity

To assess pain intensity and the level of interference in the last six months, the Graded Chronic Pain Scale (GCPS; Von Korff et al., 1992) was completed before the start of the experimental study. Items measuring pain intensity are: current pain intensity, worst pain intensity, and average pain intensity in the past six months, all answered using an 11-point Likert scale ranging from 0 (“no pain”) to 10 (“pain as bad as could be”). Items addressing pain disability are: the number of days that the participant was unable to perform his/her usual activities (work, school, or housework) during the past six months, the extent of interference with daily activities, the ability to take part in recreational, social and family activities, and the ability to work. The latter three items are scored using an 11-point Likert scale ranging from 0 (“no interference”) to 10 (“unable to carry on any activities”). Based on the pain intensity and interference, respondents can be classified in five categories: (1) Grade 0: no pain in the past six months; (2) Grade I: low pain intensity and low disability; (3) Grade II: high pain intensity, but low disability; (4) Grade III: highly disabling, moderately limiting pain; (5) Grade IV: highly disabling, severely limiting pain. The GCPS has been shown to be a valid and reliable instrument (Von Korff et al., 1992).

All of the following questionnaires were filled in before the individual appointment took place.

Pain Catastrophizing

To measure the frequency of catastrophic thoughts and feelings experienced when in pain, participants completed the Dutch version of the Pain Catastrophizing Scale (PCS; PCS-DV; Crombez, Eccleston, Baeyens, & Eelen, 1998; Sullivan, Bishop, & Pivik, 1995). The PCS comprises of 13 items,

and is scored using a 5-point Likert scale ranging from 0 (“not at all”) to 4 (“always”). The PCS yields a total score between 0 and 52, and three subscale scores: rumination (e.g., “I keep thinking about how much it hurts”), magnification (e.g., “I become afraid that the pain will get worse”), and helplessness (e.g., “I feel I can’t go on”). Internal consistency and validity of the PCS are shown to be good (Sullivan et al., 1995; Van Damme et al., 2002). Cronbach’s α for the PCS in this study was .94.

Depression, Anxiety and Stress

Participants filled in the Depression Anxiety and Stress Scales (DASS; Lovibond P. F. & Lovibond, 1995; Lovibond S.H. & Lovibond, 1995), which consists of 42 items describing negative symptoms. Respondents are asked to rate the extent to which they have experienced each of the symptoms during the past week using a scale from 0 (“not at all applicable”) to 3 (“definitely applicable”). Scores for the Depression, Anxiety, and Stress subscale are calculated by summation of the corresponding items (14 per scale). Example items are “I felt I was pretty worthless” for Depression, “I felt terrified” for Anxiety, and “I found that I was very irritable” for Stress. Internal consistency and validity of the DASS are good (Antony, Bieling, Cox, Enns, & Swinson, 1998). In this study, we found a Cronbach’s α of .97.

Trait anxiety

To measure trait anxiety, the Dutch translation of the trait version of the Spielberger State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970), called the Zelf-Beoordelings Vragenlijst (ZBV; Van der Ploeg, 1980), was completed. The STAI trait version consists of 20 items, each rated on a scale from 1 (“no anxiety”) to 4 (“very anxious”). The total score ranges between 20 and 80, with scores of 50 or above labeled as anxious. The STAI has shown to be highly valid and reliable (Spielberger et al., 1970; Van der Ploeg, 1980). Cronbach’s α for this study was .94.

Cognitive intrusions

The recently developed Experience of Cognitive Intrusion Pain scale (ECIP) was used to measure the extent to which the experience of pain interferes with thinking when experiencing pain (Attridge, Crombez, Van Ryckeghem, Keogh, & Eccleston, 2015). The scale has ten items, all scored on a 7-point Likert scale ranging from 0 (“not at all applicable”) to 6 (“highly applicable”). Items focus on interruption by pain (e.g., “pain interrupts my thinking”), ruminative thoughts on pain (e.g., “pain goes around and around in my head”), and control by pain (e.g., “I can’t push pain out of my thoughts”). The total score ranges from 0 to 60 and is obtained by summating all items. Cronbach’s α for the ECIP in this study was .97.

Positive and negative affectivity

Participants completed a Dutch version of the trait version of the Positive and Negative Affectivity Scale (PANAS; Engelen et al., 2006; Watson, Clark, & Tellegen, 1988). The PANAS consists of 20 items, 10 positive affective words (e.g., interested, cheerful), and 10 negative affect words (e.g., sad, guilty). Respondents used a 5-point Likert scale ranging from 1 ("very slightly or not at all") to 5 ("extremely") to indicate the extent to which they generally experience each of the emotions. This Dutch version of the PANAS is shown to be a reliable and valid instrument (Engelen et al., 2006). The Cronbach's α was .87 for the positive scale, and .90 for the negative scale.

The three following questionnaires were filled in by patients only.

Pain Disability

To measure the degree to which pain on average interferes with the ability to participate in daily life, we used the Pain Disability Index (PDI; Pollard, 1984). This questionnaire consists of seven items assessing the disability in each of the following domains: family and home responsibilities, recreation, social activity, occupation, sexual behavior, self-care, and life-support activity (e.g., eating) on a 11-point Likert scale ranging from 0 ("no disability") to 10 ("total disability"). The PDI is considered a reliable and valid instrument to study pain-related disability (Tait, Chibnall, & Krause, 1990). In the current study, we found a Cronbach's α of .87 for the PDI.

(Hyper)Vigilance

Patient participants completed the Dutch version the Pain Vigilance and Awareness Questionnaire (PVAQ), which contains 16 items that measure the respondent's vigilance for painful sensations during the last two weeks (McCracken, 1997; Roelofs, Peters, Muris, & Vlaeyen, 2002). Each item is rated on a scale ranging from 0 ("never") to 5 ("always"). The total score is calculated by summating all items, resulting in a total score ranging from 0-80. The validity and reliability of the PVAQ has shown to be good (Roelofs et al., 2002; Roelofs, Peters, McCracken, & Vlaeyen, 2003). Cronbach's α in this study was .87.

Pain-related fear

To asses four components—fearful appraisal of pain, cognitive anxiety, psychological anxiety, and escape and avoidance behavior—of pain-related fear, patient participants completed the Pain Anxiety Symptoms Scale (PASS; McCracken, Zayfert, & Gross, 1992). The PASS contains 40 items scored on a 6-point scale ranging from 0 ("never") to 5 ("always"). The PASS has been shown to be reliable (Burns, Mullen, Higdon, Wei, & Lansky, 2000; Roelofs et al., 2004). For the PASS, we found a Cronbach's α of .86.

Semi-structured interview

Participants completed a semi-structured interview based on the Day Reconstruction Method (DRM) of Kahneman et al. (2004), which was originally developed to study activities and affective experiences of the previous day. The semi-structured interview used here had the goal to activate memories of the previous day by letting participants reconstruct their day, and as a consequence enable them to report on experiences of goal conflict.

Reconstruction of previous day. First the interviewer explained the objective and procedure of the interview to participants. Participants first rated current fatigue and pain on a scale ranging from 0 ("no pain/fatigue") to 10 ("extremely much pain/fatigue"), indicated the date and day of the previous day, as well as the time they woke up in the morning and the time they went to bed. In contrast with the original DRM—where participants independently reconstruct their previous day by means of an anonymous diary—the interviewer asked participants to verbally report on the activities they had undertaken the previous day. The interviewer prompted participants to freely report the activities undertaken the previous day and to take the time needed to reflect on their day and their key words so participants would have a clear and complete overview of their day. Conform with the original DRM, participants were asked to report on morning (from waking until noon), afternoon (noon until about 18:00), and evening (from about 18:00 until going to bed) activities. An activity usually varies between 15 minutes and two hours, and often starts when someone new joins in, or when going to another location. The interviewer stressed that participants could express themselves in a way they felt comfortable, and that all information shared during the interview was confidential. After having fully constructed their previous day, participants were given the opportunity to look at the overview of their previous day again, and add, delete or alter activities if necessary.

Conflict mapping. Next, possible conflicts that arose that day were assessed. Conflict was defined as: "*experiencing some indecisiveness or doubt which activity to pursue. This indecisiveness or doubt about which activity to pursue takes some time, that is, a decision is not made immediately. These activities should sufficiently differ from each other, that is, they should not be based on the same act.*". This working definition of goal conflict is based on the premise that goals direct activities as they give meaning to people's lives (Baumeister, 1989), and is related to other goal constructs that reflect on personal actions, such as *current concerns* (Klinger, 1975, 1977), *personal projects* (Little, 1983, 2006), or *personal strivings* (Emmons, 1986). Some examples of conflicts were provided, such as having doubts whether to study for an exam or going out for drinks, reading a newspaper or repairing a leaky faucet, or resting to reduce pain or going for dinner with friends. The interviewer also explained that this definition does not incorporate "social conflict", that is, having a fight or an argument. In order to ensure comprehensibility, participants were asked to provide an example that fitted the definition above, and further clarification was given if necessary. Guided by the definition, participants were then asked to report as many conflicts as possible that they had experienced the

previous day. Furthermore, some detailed information concerning these conflicts was assessed, such as the activities involved, the context, reasons of conflict, duration, and decision.

Goal categorization. After having reported all conflicts, participants were asked to classify the immediately underlying goals of each of the activities involved in the conflict, for all reported conflicts. The following categories were used (Chulef, Read, & Walsh, 2001): 1) Interpersonal/Social: the goal is to maintain or improve contact or relationships with other people (e.g., going out with friends); 2) Intrapersonal: the goal is to maintain or improve personal qualities or personal growth (e.g., be helpful); 3) Work/Education: the goal is related to work and/or educational purposes, and is aimed at the personal (academic) career (e.g., following classes, meeting deadlines); 4) Household: the goal is to pursue household activities or chores, and is aimed at maintaining or improving your household (e.g., having a clean house); 5) Leisure: the goal is to relax or to enjoy yourself, mostly the goal is to pursue activities that are aimed at things you do in your spare time (e.g., hobbies); 6) Financial: the goal is to maintain or improve your financial status, freedom, independence, security or stability; 7) General physical and mental health: the goal is to maintain or improve your general physical and/or mental health, e.g., eating healthy food, stress reduction; with the exception of the goal to avoid, reduce or control pain; 8) Pain control, avoidance and/or reduction: the goal is to control, avoid or reduce pain, e.g., resting, avoiding movements, taking medication; and 9) Other: if the goal does not fit in one of the other categories, this category can be selected. Before classifying their conflicts, participants were informed that only one goal per activity could be selected, and that if multiple categories were suitable, participants should select the most important one. A list of the goal categories was placed in front of the participant as a reminder. The interviewer also illustrated how to classify the goals of the activities using an example:

> *"Imagine sitting in a restaurant and doubting between staying for a chat with your friend, or going back to work. You may want to chat with your friend because you want to invest in the relationship with your friend. This can be placed in the category "social/interpersonal". You may want to go back to work because you wish to do the work you are meant to do; this can be classified in the category "work/education". However, it is also possible that you wish to go back to work because you want to be a professional and hard-working person, which can be classified in the category "intrapersonal". Another goal you may have, is to obtain a financial bonus; this can be placed in the category "financial". Since multiple goals are present, you have to pick the one that was most applicable in that situation, for example, "work"."*
>
> Next, participants themselves classified all their conflicts in the categories they deemed fit.

Conflict assessment. After having classified all conflicts, participants were asked to assess a maximum of three conflicts. In case more than three conflicts were reported, the three conflicts were selected at random (using a randomization table). Questions regarding goal conflict involved conflict strength *("How strongly did you experience this conflict?"*), worry ("*To what extent did you worry*

during this conflict?"), pain-related worry ("*To what extent did you worry about pain during this conflict?*"), stress ("*To what extent did you feel stressed during this conflict?*"), need of support ("*To what extent did you need support during this conflict?*"), conflict solution ("*How difficult was it to solve this conflict?*") and solution satisfaction ("*How satisfied were you with the solution of this conflict?*"). Additionally, participants rated their affect during the conflict (11 items, e.g., happiness, sadness, relaxation, frustration). All questions were assessed on a 5-point Likert scale going from 0 (not at all) to 6 (very much).

Assessment of previous day. Lastly, participants assessed their pain, fatigue, emotions, and general experience of that day (for a detailed description, see PAM-I-Protocol). As the main focus of this paper is on the presence and experience of conflict, and the relationship with FAM constructs, we do not perform analyses with these variables.

Results

All analyses reported here were run using SPSS 23.0 and Microsoft ® Excel 2010. Alpha was set at .05.

Do patients experience more goal conflict than healthy participants?

The primary aim of the current study was to determine the presence of goal conflict in a patient sample compared to controls, and investigate whether both groups differ. Since the assumption of normality was violated, we report Mann-Whitney U tests when comparing the average ranks of the number of conflicts between groups. Patients on average reported 1.53 ± 1.13 goal conflicts (range: 0-4). The total number of conflicts reported by patient participants was 61. Control participants reported on average 1.87 ± 1.46 goal conflicts (range of 0-7). The total number of conflicts reported by control participants was 69. There was no significant difference between patients and controls regarding the average ranks of the number of conflicts $U = 665.5$, $p = .431$. Figure IV.1.1 presents the number of participants reporting either no, 1, 2, 3, or more than 3 goals as a function of group.

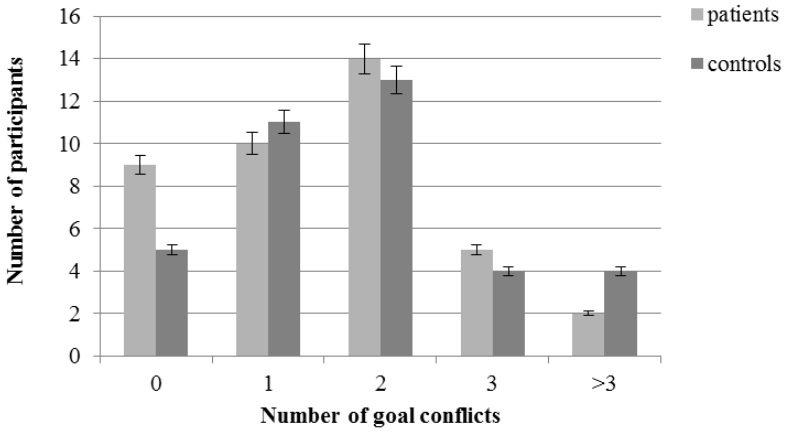

Figure IV.1.1. Frequency of reported goal conflicts as a function of group.

Do patient and healthy participants differ in the type of conflict experienced?

Another aim was to explore whether patients and controls differ in the type of conflicts they experience. More specifically, a motivational account of the Fear-Avoidance model posits that pain-avoidance goals may compete with other activities or goals for patients with chronic pain. Therefore, we expected that patients experience more pain-related goal conflict than control participants.

To assess whether patients report certain types of conflict more often than control participants, we first coded if the conflict contained that goal (yes, coded as '1) or not (no, coded as '0') per goal category. For example, a goal conflict was coded as "pain-related goal conflict" when at least one of both goals involved pain control, avoidance and/or reduction, and so forth. Next, we summed the number of conflicts reported per participant per type of conflict, e.g., pain-related goal conflict. Mann-Whitney U tests are reported since the assumption of normality was violated. Our tests revealed that on average, patients with fibromyalgia reported more pain-related goal conflicts than control participants, 0.875 ± 0.991, and 0.054 ± 0.229, respectively, $U = 363$, $p \leq .001$. As shown in Table IV.1.1, 55% of the patients report at least one pain-related goal conflict during the previous day, whereas only 5.4% of controls do so. Furthermore, patients with fibromyalgia on average reported less work-related goal conflicts, $U = 363$, $p \leq .001$, less social-related conflicts, $U = 534.5$, $p = .021$, and less pleasure-related goal conflicts, $U = 499.5$, $p = .004$. Patient and control participants did not differ in the average number of health-related, finance-related, household-related, and intrapersonal-related goal conflicts, ps > .05.

Table IV.1.1

Frequency and percentage of participants reporting pain-related goal conflict

number of pain-related conflicts	Total (N=77)		Patients (N=40)		Controls (N=37)	
	N	*%*	*N*	*%*	*N*	*%*
0	53	68.8	18	45	35	94.6
1	14	18.2	12	30	2	5.4
2	8	10.4	8	20	0	0
3	1	1.3	1	2.5	0	0
>3	1	1.3	1	2.5	0	0

Which goals are most commonly conflicting with pain avoidance, control, and/or reduction?

Of 40 patients, 31 reported at least one goal conflict. Similarly, 32 out of 37 control participants reported at least one goal conflict. As mentioned above, patient and control participants reported 61 and 69 goal conflicts in total, respectively. Of the 61 goal conflicts reported by patients, 35 (57.4%) goal conflicts were pain-related, whereas only 2 out of 69 (2.9%) goal conflicts reported by control participants were pain-related. Following up on the finding that patients report more pain-related goal conflict than control participants, we additionally explored which goals most often conflict with pain avoidance. For patients, the goal to avoid, control or reduce pain most often conflicted with household goals (45.7%), social goals (20%), and intrapersonal goals (14.3%). Furthermore, pain-related goals conflicted with other health-related goals in 8.6% and with financial goals in 5.7% of reported conflicts. For controls, the 2 pain-related goal conflicts involved pleasure goals and household goals, respectively.

Do patient and healthy participants differ in the experience and context of conflict?

Although we did not find any differences in terms of the number of goal conflicts, we expected that patients might experience conflicts as more aversive, and might experience more difficulties in resolving their conflicts. The analyses on the experience of conflict were conducted on the conflict level, meaning that the data reflects the responses of 31 patients and 32 controls, since questions regarding a goal conflict were only answered when a conflict was reported. Furthermore, if participants reported more than 3 conflicts, data was collected on maximally three of these conflicts (see "Semi-structured interview: conflict assessment"). As a result, 8 conflicts reported by controls and 2 conflicts reported by patients were excluded from the analyses. The analyses were run on 61 conflicts reported by 32 controls and 59 conflicts reported by 31 patients.

The context of the conflicts pertains to whom the subject was with during the conflict, where the participant was (location), if the conflict was caused by another person, and how they solved the conflict. The frequency and percentage of participants per group is described in Table IV.1.2. If patients experienced a conflict, they most often were alone (49.2%) or with their family/partner (44.3%). Controls were also most often alone (55%) when experiencing a conflict. The majority of conflicts reported by patients occurred at home (86%), whereas this is less the case for conflicts reported by control participants (58%). School or work accounts for 17.4% of conflicts reported by control participants. For both groups, the conflict was not introduced by a third party, and the conflict was resolved by doing only one of the activities involved in the conflict.

Table IV.1.2

Frequency and percentage of conflicts per group for the variables who, location, cause, and conflict solution

	Total		Patients		*Controls*	
	N	*%*	*N*	*%*	*N*	*%*
Who						
alone	68	52.3	30	49.2	*38*	*55.1*
family/partner	45	34.6	27	44.3	*18*	*26.1*
friends/acquaintances	4	3.1	0	0	*4*	*5.8*
colleagues/fellow students	5	3.8	0	0	*5*	*7.2*
other	4	3.1	2	3.3	*2*	*2.9*
multiple categories	4	3.1	2	3.3	*2*	*2.9*
Location						
at home	93	71.5	53	86.9	*40*	*58*
on the way	10	7.7	3	4.9	*7*	*10.1*
visiting family/friends/acquaintances	4	3.1	0	0	*4*	*5.8*
work/school	13	10	1	1.6	*12*	*17.4*
other	10	7.7	4	6.6	*6*	*8.7*
Conflict caused by someone else						
No	98	75.4	44	72.1	*54*	*78.3*
Yes	32	24.6	17	27.9	*15*	*21.7*
Conflict solution						
Perform 1 of both activities	85	65.4	41	67.2	*44*	*63.8*
Do both activities (sequentially)	45	34.6	20	32.8	*25*	*36.2*

We investigated whether patients and controls differ in the experience of conflict, and to what extent the experience of conflict varies as a function of the number of conflicts. Therefore, we ran multilevel analyses on our outcome variables, to account for the dependency in our data. Prior to the multilevel analyses, we ran a principal component analysis on 11 affect-items. The scree plot analysis revealed 2 factors with an Eigenvalue greater than 1 explaining 74.24% of the variance. The factors created as a result of the factor analysis were 1) positive affect, which contains the variables happy, enthusiastic, and relaxed; and 2) negative affect, which contains the variables sad, nervous, irritated,

angry, afraid, powerless, frustrated, and helpless. We ran multilevel models (assuming conflicts are nested within persons) for the log(conflict duration), conflict strength, satisfaction, difficulty, worry, worry about pain, stress, positive affect, and negative affect. The predictor variables included in the model were group (controls = 0, patients = 1), the number of conflicts and the interaction between these variables. The number of conflicts was centered using grand mean centering, so that a value of 0 reflects an average number of conflicts. For each of the dependent variables, a random intercept model was estimated. Standard errors for estimated parameters are calculated using bootstrapping to increase accuracy, as our sample is small and dependent variables are not always normally distributed. The results of the analysis are presented in Table IV.1.3.

The estimated coefficient for group indicated that, compared to controls, patients reported to worry more overall during conflicts, β_a = .602, *SE* = .278, *p* = .019, and also more about their pain, β_a = 2.48, *SE* = .274, *p* < .001, reported to be more stressed during a conflict, β_a = 1.33, *SE* = .26, *p* < .001, more strongly felt they needed more social support during conflicts, β_a = 1.05, *SE* = .267, *p* < .001, found their conflicts more difficult to solve, β_a = -.84, *SE* = .238, *p* < .001, were less satisfied with how they solved their conflict, β_a = -.84, *SE* = .269, *p* < .001, experienced less positive feelings, β_a = -.66, *SE* = .198, *p* = .001, and more negative feelings during the conflict, β_a = .71, *SE* = .203, *p* = .001. Furthermore, assuming an average number of conflicts, it took patients longer than controls to solve their conflicts, β_a = .92, *SE* = .22, *p* < .001. The slope for the number of conflicts predicting duration of conflict was significantly greater for patients than for controls, $\beta_{a\times b}$ = .57, *SE* = .196, *p* = .001. Lastly, (assuming an average number of conflicts) patients reported to experience their conflicts more strongly than controls, β_a = .791, *SE* = .177, *p* < .001. The slope for the number of conflicts predicting conflict strength was significantly greater for patients than for controls, $\beta_{a\times b}$ = .36, *SE* = .156, *p* = .007. The number of conflicts did not alter the experience of conflict in either of the groups for all other outcome variables.

Table IV.1.3

Multilevel regression analyses for experience of conflict outcome variables

Outcome variable	**Predictors**												**Variance components**			
	Intercept			**Group**			**Number of Conflicts**			**Interaction**			**Error term**		**random intercept**	
	β_o	*SE*	*p*	β_a	*SE*	*P*	β_b	*SE*	*p*	$\beta_{a\times b}$	*SE*	*p*	$\sigma^2(\varepsilon_{ij})$	*p*	$\sigma^2(u_{0j})$	*p*
Log(duration)	5.29	.171	<.001	.922	.22	<.001	-.16	.122	.116	.57	.196	.001	.872	.600	1.826	<.001
Conflict strength	3.39	.136	<.001	.791	.177	<.001	-.01	.099	.921	.36	.156	.007	.849	.460	.779	<.001
Worry	2.4	.198	<.001	.602	.278	.019	-.15	.151	.232	-.03	.254	.888	1.89	.473	2.076	<.001
Worry about pain	.64	.16	<.001	2.48	.274	<.001	-.01	.073	.914	-.33	.269	.130	2.312	.424	1.131	.084
Stress	1.94	.18	<.001	1.33	.26	<.001	-.002	.138	.989	.04	.266	.849	1.73	.510	1.752	<.001
Need for support	.92	.164	<.001	1.05	.267	<.001	-.05	.088	.448	.21	.254	.308	1.985	.409	1.158	.007
Difficulty to solve	2.42	.16	<.001	.84	.238	<.001	.13	.136	.231	.002	.257	.993	1.462	.403	1.152	<.001
Satisfaction with solution	4.5	.172	<.001	-.84	.269	<.001	-.07	.112	.363	.07	.273	.740	2.65	.185	0	1
Positive affect	2.08	.156	<.001	-.66	.198	.001	.06	.147	.658	-.23	.242	.233	.845	.517	1.42	<.001
Negative affect	1.29	.142	<.001	.71	.203	.001	-.05	.091	.558	.31	.192	.068	.726	.454	1.692	<.001

Note. Betas (β) indicate estimates. SE = Standard Error, calculated using bootstrapping. σ^2 (ε_{ij}) = variance of the error term; $\sigma^2(u_{0j})$ = variance term of the random intercept.

Can core constructs of the Fear-Avoidance model or individual differences predict the number of (pain-related) goal conflicts?

Lastly, as the Fear-Avoidance model proposes that several factors might play a role in the development of pain-related fear, avoidance, and disability, we additionally explored if the amount of pain-related goal conflict—reflected by the number of pain-related goal conflicts—could be predicted by individual differences in process outcomes—such as pain-related fear, catastrophizing, and hypervigilance—individual states and traits, such as general anxiety, and individual differences in disability and pain.

Poisson regressions were carried out to assess whether individual differences predicted the number of *pain-related* goal conflicts. Since only two control participants had a pain-related goal conflict, regressions were carried out with the patient group only (*N*=40). Measures assessing traits/states included were: positive and negative affect (PANAS), trait anxiety (STAI), Depression, anxiety and stress (DASS), pain catastrophizing (PCS), pain disability (PDI), hypervigilance (PVAQ), pain-related fear (PASS), and cognitive intrusions (ECIP). We also assessed individual differences in disability, years of pain onset, average pain (in a week), pain intensity, and hindrance by pain. We corrected for over- or under-dispersion using a quasi-Poisson approach. Our results indicated that the average number of pain-related goal conflicts reported by patients increased 39.6% for each increase of one standard deviation in average pain, β = .396 (95% CI:.013; .778), *Wald* χ^2 = 4.11, *df=1*, *p* = .043, 4.3% for every standard deviation increase in anxiety (DASS), β = .043 (95% CI:.002; .082), *Wald* χ^2 = 4.28, *df=1*, *p* = .039, and 2.5% for each increase of one standard deviation on cognitive intrusions, β = .025 (95% CI: .006; .043), *Wald* χ^2 = 7.011, *df=1*, *p* = .008. A marginally significant increase of 3.3% and 3.1% in the average number of pain-related conflicts reported were found for an increase of one standard deviation in negative affect, β = .033 (95% CI:-.001; .067), *Wald* χ^2 = 3.6, *df=1*, *p* = .058, and depression, β = .031 (95% CI:-.002; .064), *Wald* χ^2 = 3.29, *df=1*, *p* = .07, respectively. None of the other individual difference variables predicted the number of pain-related goal conflicts: Pain catastrophizing: β = .018 (95% CI: -.011; .047), *Wald* χ^2 = 1.52, *df=1*, *p* = .218; positive affect: β = -.025 (95% CI:-.078; .029), *Wald* χ^2 < 1, *df=1*, *p* = .365; trait anxiety: β = .017 (95% CI: -.013; .048), *Wald* χ^2 = 1.21, *df=1*, *p* = .272; stress (DASS): β = .023 (95% CI: -.011; .056), *Wald* χ^2 = 1.79, *df=1*, *p* = .181; Pain disability: β = .02 (95% CI:-.011; .051), *Wald* χ^2 = 1.56, *df=1*, *p* = .212; hypervigilance: β = .022 (95% CI:-.006; .050), *Wald* χ^2 = 2.35, *df=1*, *p* = .125; Pain-related fear: β = .010 (95% CI:-.002; .023), *Wald* χ^2 = 2.72, *df=1*, *p* = .099; disability: β = -.093 (95% CI:.-835; .649), *Wald* χ^2 < *1*, *df=1*, *p* = .806; years of pain onset: β = -.017 (95% CI:-.050; .017), *Wald* χ^2 < *1*, *df=1*, *p* = .323; pain intensity: β = .186 (95% CI: -.204; .576), *Wald* χ^2 <*1* , *df=1*, *p* = .351; hindrance by pain: β = .244 (95% CI:-.082; .530), *Wald* χ^2 = 2.06, *df=1*, *p* = .151.

Discussion

The primary aim of the current study was to determine the presence and experience of goal conflicts in patients with fibromyalgia compared to healthy controls. For this purpose, 37 healthy participants and 40 patient participants completed a semi-structured interview in which they identified experienced goal conflicts, assessed the experience of the conflict, classified each of their goals in pre-defined categories, and assessed their previous day. Although exploratory in nature, this study provides novel findings and increases our understanding of the dynamics of goal conflict in chronic pain patients.

First, we expected that patients would overall experience more goal conflict than control participants. However, our results point out that patients did not spontaneously report more goal conflicts than healthy control participants, which contradicts with the suggestion of Karoly and colleagues (2008) that patients report more goal conflict overall. Second, we expected pain patients and controls to differ in the type of conflicts they experience. More specifically, we expected that patients' goal conflicts would revolve around pain avoidance and control more often than control participants' goal conflicts. We indeed found that patients reported more pain-related conflicts. Additionally, patients also reported less conflicts related to work, social, or pleasure goals. Of all conflicts reported by patients, 57.4% involved a pain-goal, which further demonstrates the extent to which pain goals interfere with other goals. Pain goals most often conflicted with household goals (45.7%), social goals (20%) and intrapersonal goals (14.3%). Note that these differences in type of conflict as well as the goals conflicting with pain goals might be due to contextual characteristics, as the participants in our study were mostly women, unemployed and/or receiving disability benefits.

Our study is one of the first to reveal the presence of pain-related goal conflicts, and provides preliminary evidence that pain goals indeed interfere with other goals in the daily life of patients, and as such, the inclusion of a broad motivational perspective in the Fear-Avoidance model is warranted (Crombez et al., 2012; Vlaeyen & Linton, 2012). During the interview, one of our participants described her pain-related conflicts as follows:

> "*I wanted to do some vacuuming and some dusting. I really pride myself in having a clean house…but then there is that pain again, and I start doubting: should I rest, watch a bit more TV? Or should I ask Tom to do it? […] I was resting, and then Daisy called. Asking me to go shopping with her. She needed a new dress. I did not plan for that. After cleaning, I was so tired I needed my rest…I hated to refuse, but I also did not want the pain to get worse […]"*

Another aim was to study the contextual characteristics and the affective experience of the conflict. More specifically, we expected that patients would experience conflicts as more aversive (that is, experience more negative feelings, more worry and more stress), would have more difficulty in solving their conflicts, and would feel less satisfied with how they solved their conflicts. Regarding

the contextual characteristics, our findings demonstrate that patients experienced most of their conflicts at home (86%), whereas this is less the case for control participants (58%)—who also reported experiencing conflicts at work/school or when on their way—, which again may be due to the low employment rate and disability benefits of our patient sample. Both patients and controls reported that they most often experienced a conflict when they were alone. Furthermore, despite the absence of a difference between patients and controls in the number of conflicts they report, they did differ in how they perceive conflict. Overall, it seems that patients experienced conflicts more negatively, as they experienced both less positive and more negative feelings, worried more, felt more stress, and felt more need for support. They also perceived their conflicts as more difficult to solve than control participants and it took them longer to solve them. Lastly, patients were in general less satisfied with how they solved their conflicts than control participants. Interestingly, the number of conflicts a participant experienced had little to no impact on the specific experience of conflict. Our findings are in line with those of Hardy and colleagues (2011), who studied the relation between goal conflict and fatigue and pain in a sample of 27 females with fibromyalgia. For this purpose, these women were asked to assess pain, distress, and fatigue both in the morning and in the evening, and rated their goals and goal conflict in the evening for five consecutive days. They found that pain increased more from morning to evening on days with higher conflict, and women with more symptoms reported more goal conflict than women with fewer symptoms. Taken together, our findings suggest that goal pursuit, and more specifically, goal pursuit in the face of pain, may deplete resources in an already vulnerable population, which may in turn result in more pain and fatigue, or feeling more hampered by it. However, further scientific inquiry is needed to explicitly test these relationships.

The last aim of the current study was to investigate whether individual differences in disability and pain and in core constructs of the Fear-Avoidance model could predict differences in the amount of pain-related goal conflict. First, we found that higher average pain intensity was associated with a strong increase in the number of pain-related conflicts patients reported to experience. As these results are correlational in nature, this might indicate that experiencing intense pain may lead to more goal conflict, or conversely, that conflict leads to an increase in pain (Hardy et al., 2011). The relation between pain intensity and the experience of goal conflict, as well as the solution thereof, warrant further scrutiny. Second, we found that the number of pain-related goal conflicts was associated with a higher number of cognitive intrusions (Attridge et al., 2015) as well as more anxiety (Antony et al., 1998; De Beurs, Van Dyck, Marquenie, Lange, & Blonk, 2001; P. F. Lovibond & Lovibond, 1995). Given the importance of pain-related fear and catastrophizing in the Fear-Avoidance model, we also expected that the greater pain-related fear, and the more catastrophizing, the more conflicts patients would experience. However, our study was not able to demonstrate an impact of pain-related fear, pain catastrophizing, pain disability, or hypervigilance. It may be that these constructs not necessarily predict the *number* of pain-related conflicts, but the *experience* of conflict. Further research is needed to confirm this hypothesis. Nonetheless, our results demonstrate that expanding the Fear-Avoidance

model with a broad motivational perspective is fruitful, as they suggest that goal conflict or competition in chronic pain is related to the interpretation of a situation as catastrophic, fueled by cognitive intrusions and anxiety, rather than pain-related fear. As indicated above, another intriguing question is whether the experience of pain-related conflicts differs from the experience of non-pain-related conflicts. However, this question requires an analysis of the type of goal conflict within-subject. Unfortunately, this can only be tested in our patient sample, and only a limited number of pain and non-pain related goal conflicts are reported, resulting in insufficient power to conduct those analyses on the current dataset.

This study may have clinical implications. Not only do the obtained results underscore the importance of the inclusion of goal dynamics in our understanding of chronic pain problems (Crombez et al., 2012; Vlaeyen & Linton, 2012; Vlaeyen et al., 2009), they also provide evidence for the use of treatments focusing on idiosyncratic goal pursuit in other domains aside from pain control and avoidance to improve patients overall well-being and increase physical activity (e.g., Motivational interviewing; Ang et al., 2007; Jensen et al., 2003). In this paper, we focused on the presence and experience of goal conflicts in a patient sample. Therefore, we only reported if participants pursued none, only one or both goals, but not which specific goal was pursued. It may be fruitful to assess the specific choices participants make. More specifically, future research might want to assess to what extent patients pursue pain avoidance at the expense of other goals. Our own experience while conducting the interviews suggests that often, pain avoidance often prevails over other activities, although this is not always the case. As this participant for example described:

> "*Often, when my friends call to ask me to go shopping with them, I have to refuse. I just cannot risk the pain to get worse. I would love to have fun with them, but…walking around, carrying bags, it just puts too much strain on my back. If I would do it, and the pain gets worse, that is the end of everything. That means sitting in the couch or lying in bed more than I already do, and I really don't want that…"*

When asked about spending quality time with her husband however, the participant said:

> "*Well, my pain already puts a lot of strain on our relationship, as Tom has to help out more in the house because I cannot do it anymore. He is so sweet and takes such good care of me. I think he really deserves it, even if it means a bit more pain than I would normally have."*

Therefore, we suggest that future research investigates whether patients focus on one strategy— that is, prioritizing pain avoidance over other activities—when repeatedly being confronted with a particular type of goal conflict.

Additionally, it might be appropriate to screen for certain individual characteristics such as general anxiety, as these individuals might benefit more from a tailored treatment strategy, since our research suggested that these individuals might experience more pain-related goal conflicts. However, more insight is needed on which patients experience more goal interference than others, or for which patients pain-related goal conflicts weighs more on their physical and psychological well-being.

Some limitations should be considered. A major limitation of our study is the relatively small sample size, and the limited generalizability of our findings to a broader population of patients with chronic pain. In a related vein, it is possible that the individuals who participated only represent a subset of the general population or patients with fibromyalgia respectively, as they self-selected to participate in scientific research. Our findings are limited to patients with fibromyalgia seeking health care, and may not be readily translated to those who are functioning outside the health care system, or to patients with other chronic pain problems. Therefore, future research might answer these research questions in different pain populations. Another limitation is the retrospective nature of our study design. Although the daily reconstructed method (Kahneman et al., 2004) is well-validated and helps individuals recreating their previous day in a structured way, it might be possible that feelings during the interview influenced what participants recalled. Furthermore, as the participants themselves could report and classify their goals, the interviewer had less control over what the participant reported. Related to the previous limitation, is the fact that no inferences can be made on the directionality of our results, as our findings are correlational in nature. To increase control of the interviewer, reduce recall biases, and possibly study causality, future studies may consider event-sampling procedures (Reis & Gable, 2000).

This study provides more insight in the dynamic relations between pain-related and other goals and their impact on daily life. At the same time they provide a good starting point to further study the impact of pain-related goal conflict in patients with chronic pain. It seems that goals competing for resources differ between patients and controls, with a more prominent role for pain-avoidance and –control in the lives of pain patients. Furthermore, our results suggest that patients experience conflict more aversively than healthy controls. However, further scientific inquiry is required to uncover the potential detrimental impact of pain-related goal conflict on daily life experience.

GENERAL DISCUSSION

In this final chapter, we will start with a brief overview of the theoretical framework and the resulting research aims. Next, we will broadly summarize the findings and present an integrated discussion of these findings. Subsequently, the possible theoretical and clinical implications will be examined. We will end this dissertation with a discussion of the strengths and limitations of the presented research, along with suggestions for future research.

Theoretical framework and research aims

Initially, pain was considered the unique result of tissue pathology. This strict *biomedical* approach however fails to provide a gratifying explanation for chronic pain. Instead, conceptualizing illness—and as a consequence pain—as a complex interaction of biological, psychological and social factors appears to be a more satisfying approach (Gatchel et al., 2007). One of the most successful *biopsychosocial* models used to explain chronic pain development is the Fear-Avoidance model (Lethem et al., 1983; Vlaeyen & Linton, 2000, 2012). The Fear-Avoidance model essentially describes two pathways of responses to the experience of pain. The first pathway is a non-catastrophic interpretation of pain, whereby the patient confronts him/herself with painful activities, which ultimately leads to being active despite pain. The second pathway however consists of a catastrophic misinterpretation of pain, resulting in the development of pain-related fear, and consequently in defensive behavior such as avoidance, escape and hypervigilance, ultimately leading to disability, suffering, and (more) pain. Despite the wealth of evidence identifying pain-related fear and avoidance behavior as key factors in the development and maintenance of chronic pain, thus corroborating the validity of the Fear-Avoidance model (Gheldof et al., 2010; Jensen et al., 2010; Leeuw, Goossens, et al., 2007; Turk & Wilson, 2010; Van Damme et al., 2012; Vlaeyen & Linton, 2000; Wideman et al., 2009), some concerns have been raised regarding these models (Crombez et al., 2012; Van Damme et al., 2012; Vlaeyen et al., 2009). More specifically, one of the challenges is expanding the Fear-Avoidance model by including the motivational context. Indeed, pain-related fear does not occur in a motivational vacuum, and the goal to avoid pain is only one goal in a dynamic context of competing goals (Christiansen et al., 2010; Crombez et al., 2012; Van Damme et al., 2008; Wiech & Tracey, 2013).

Recently it has been suggested that individuals experiencing chronic pain often pit the costs and benefits of pain avoidance against those of other valued activities (Gandhi et al., 2013; Roy, 2010; Talmi et al., 2009; Van Damme et al., 2012). In line with these findings, the pathway of confrontation of the Fear-Avoidance model may be formulated as the prioritization of other life goals over pain avoidance. The patient weighting work as more important than avoiding pain might engage in physical activities, despite pain. On the other hand, it may very well be that the pain-avoidance goal is prioritized, at the expense of the attainment of other life goals. And indeed, one of the most debilitating consequences of pain-related avoidance behavior is the withdrawal from previously valued activities.

Notwithstanding the important theoretical and clinical implications of incorporating a motivational dimension to study chronic pain, research investigating the influence of competing goals on pain-related fear and associated defensive responding, such as avoidance behavior, is scarce (Crombez et al., 2012; Schrooten, Vlaeyen, et al., 2012). Therefore, the overall aim of this dissertation was to investigate how motivational context, and more competing goals and pain-related goal conflict in particular, impact on pain-related fear and avoidance behavior.

1. First, we presented two experimental studies investigating whether introducing a concurrent reward, serving as a competing goal, would impact pain-related fear and avoidance behavior in a healthy population
2. Second, we investigated whether various types of goal competition have a differential impact on pain-related fear and pain-related decision-making in a healthy population
3. Third, we presented two studies investigating the impact of context cues on pain-related fear and avoidance behavior
4. Fourth, an observational study was conducted in a patient sample, in which we studied the presence and nature of goal conflict.

Summary of the findings

Part I: The impact of a competing approach goal on pain-related fear and avoidance behavior

Literature on goal competition in the context of pain is scarce, and therefore little is known how concurrent—possibly interfering—goals might impact on pain-related fear and associated avoidance behavior. We hypothesized that presenting a concurrent reward alongside a painful stimulus would diminish pain-related fear and avoidance behavior as compared to the presentation of the painful stimulus alone. In **experiment I.1 (Chapter I.1)**, healthy participants completed a modified version of the Voluntary Joystick Movement Paradigm (VJM paradigm; e.g., Meulders, Vansteenwegen, & Vlaeyen, 2011, 2012; Meulders & Vlaeyen, 2012). Participants performed safe movements and painful movements that were either presented with (experimental condition) or without (comparison condition) a concurrent reward. The results indicate that after successful differential contingency learning, participants were less hesitant to perform the painful movement when it was accompanied by a concurrent reward, compared to when the reward was absent. Furthermore, participants also showed less frequent avoidant decision making behavior when pain was accompanied by a reward than when pain was presented alone. This finding is in line with literature that a valuable incentive is capable of diminishing avoidance tendencies (e.g., Cabanac, 1986; Gandhi et al., 2013). However, the diminution of response latencies may have been caused by the possibility to mentally prepare (Mir et al., 2011). Based on learning theories, we hypothesized that pain-related fear would diminish when a concurrent reward accompanied pain as a concurrent reward is theorized to alter the valence of a painful movement. Alternatively however, literature has shown that patients

report more pain-related fear when experiencing goal conflict (Karoly et al., 2008), and we thus might observe an increase in pain-related fear. Contrary to our original hypothesis and the findings in a clinical population, pain-related fear remained unaltered when a concurrent reward accompanied pain. This finding is however in line with previous research indicating that the addition of a monetary incentive does not necessarily reduce pain-related fear (Leeuw, Goossens, et al., 2007; Van Damme et al., 2012). Furthermore, additional analyses pointed out that the importance of pain-avoidance rated by participants was positively associated with avoidance behavior, whereas the importance of obtaining the reward was negatively associated with avoidance behavior. Pain-related fear however, was not a significant predictor of avoidance behavior. These findings suggest that although pain-related fear remains unaltered, both pain and appetitive (reward) goals impact on behavioral decision making and avoidance behavior: a concurrent reward may attenuate avoidance behavior in the context of pain. There were however some limitations that may have contributed to our findings, such as the post-hoc assessment of goal importance, and a confound among the measurement of self-reported pain-related fear and pain expectancy. In **experiment I.2 (Chapter I.2)**, a similar experimental set-up was used in order to replicate the findings of experiment I.1, as well as overcoming some of its limitations. Given that individuals often have to choose which goal to pursue, regularly resulting in the disengagement from other goals (Boudreaux & Ozer, 2012; Eccles & Wigfield, 2002), a second aim of this experiment was to investigate the (modulatory) effect of goal prioritization—favoring one goal over the other—on pain-related fear and avoidance behavior when presented with a concurrent reward. Hitherto, based on their self-reported identification of the most important goal for the experiment, we divided participants in three separate goal groups: *pain-avoidance*, *reward-seeking*, and *equally important*. As was the case in Experiment I.1, avoidant decision-making was attenuated when the reward accompanied pain, whereas it did not impact on pain-related fear. Furthermore, results indicated that preferring to obtain the reward was associated with overall lower pain-related fear compared to prioritizing pain or deeming both goals equally important. Also, it was shown that when given the choice, participants preferring the reward performed more painful movements than participants considering both goals equally important, who in turn performed more painful movements than participants prioritizing pain avoidance. We however did not replicate the finding that participants were less hesitant to perform a painful movement when a reward was present compared to when it was absent; participants hesitated to perform a painful movement, irrespective of the presence of the reward, and irrespective of their preferred goal. This difference in findings may have been caused by a difference in preparation, as in Study I.1, participants could mentally prepare for a movement, whereas in Study I.2, they could not. Interestingly, we also found that goal prioritization was associated with behavioral persistence. Pain-avoiders persistently avoided the painful movement when it was presented without the reward, whereas they performed more painful movements when the reward was presented; a similar yet opposite pattern was found for reward-seekers: they more persistently performed the painful movement when the reward accompanied pain, and alternated more

between the painful movement and safe movement when the reward was absent. The studies in part I are notable for their use of a well-established experimental research paradigm to study the influence of concurrent rewards and goal competition on pain-related fear and avoidance behavior. Both studies thus seem to suggest that despite the fact that pain-related fear remains unaffected, a concurrent reward is capable of diminishing pain avoidance in healthy subjects. This finding demonstrates that in the context of pain, like in other contexts, valuable incentives are capable of diminishing avoidance. The second experiment further demonstrated that this is especially the case in those who prioritize earning the reward over pain avoidance. This study is one of the first to explicitly study the impact of goal prioritization on defensive pain responding. Our findings may be explained from a motivational perspective, and the hedonic principles—that is, the governance of behavior by pain and pleasure—may provide a viable explanation for our findings. Alternatively, other principles, such as regulatory anticipation—based on expectations—and differences in learning history may have contributed to our findings.

Part II: the effect of multiple goal conflicts on pain-related fear and avoidance behavior

In Part I, we only studied the impact of one type of goal competition—that is avoidance-approach competition—on pain-related fear, avoidance behavior, and avoidant decision making. However, several types of goal competition can be distinguished (Lewin, 1935; Miller, 1944). In **experiment II.1 (Chapter II.1)**, we set out to investigate the effect of different types of goal competition on pain-related defensive responding and decision-making. Healthy subjects participated in a cross-directional movement task, in which each movement was eventually associated with either one or two different outcomes (pain, safety, reward, loss of reward), enabling us to create different types of goal competition: (a) approach-approach: safety and reward; (b) avoidance-avoidance: pain and loss of reward; (c) approach-avoidance: safety and loss of reward; and (d) avoidance-approach: pain and reward, which was also studied in part I. Our results were in line with the general literature on goal conflict: pain-related fear was highest for avoidance-avoidance competition, and lowest for approach-approach competition, with both approach-avoidance competitions situated in between. In general, it seems that when the competition involved the administration of pain, fear was higher than when it involved safety. A similar pattern of results for participant's willingness to perform the specified movement was found. It also seems that participants came to their decision relatively fast when presented with congruently negative (avoidance-avoidance competition) or positive (approach-approach competition) outcomes. When choosing *between* outcomes, participants seemed to be especially conflicted—resulting in slower responding—when being placed between two negative outcomes as opposed to all other competition types. These findings seem to provide preliminary experimental evidence for the differential impact of various types of goal competition on pain-related fear and decision-making. Our findings are in line with existing literature that actions are governed by value—that is, decreased by pain, and increased by reward; as indicated by expectancy-value

models—and that decision-making in the face of conflict are associated with longer response latencies. The study is notable for the introduction of a novel experimental design to examine the impact of different types of pain-related goal competition on a controlled way by introducing both positive and negative stimuli, addressing the recent call to further experimental research on the specific causal relationships between (mutually exclusive) competing goals and pain and decision-making. Our results can be interpreted in light of decision-making and motivational theories, but other (alternative) explanations may be plausible as well. For one, as in Part II, regulatory anticipation, context characteristics, and differences in learning history may have contributed to our results. Furthermore, it is possible that there is an inequality in the salience and valence of the different outcomes, as well as differences in perceived probability. We discuss these alternative explanatory mechanisms below (see Integrated discussion of findings).

Part III: The impact of environmental cues predicting (dis)similar outcomes on pain-related fear and avoidance behavior

It is argued that human behavior in general is goal-directed, and that goal-directed behavior may be modulated by environmental cues (Doya, 2008). The same might be true for pain-related behavior. In two experiments, we set out to investigate the impact of Pavlovian cues on pain-related fear as well as avoidance behavior and avoidant decision making, a topic of scientific inquiry that has received little to no attention in the context of pain, but is widely studied in reward settings. Based on the literature of Pavlovian-to-Instrumental Transfer (PIT; e.g., Cohen-Hatton et al., 2013; Holmes et al., 2010), we hypothesized that cues predicting pain would result in an increase in pain-related fear and avoidance, whereas cues predicting reward would result in a decrease in pain-related fear and avoidance. In **Experiment III.1**, three different CSs associated with either pain, reward, or nothing (=neutral) were integrated in a joystick movement task, in which one movement was painful and another movement was accompanied with reward. The results were in line with our predictions: the presence of a pain CS enhanced pain-related fear and diminished eagerness and willingness to perform the movement, whereas a reward CS resulted in a decrease in pain-related fear and an increase in eagerness and willingness. These results extend existing literature showing that cues associated with pain are capable of incrementing fear, but also interfering with pleasurable activities (e.g., Notebaert et al., 2011). An intriguing observation was that the neutral CS did not seem to be neutral, but seemed to evoke similar behavior as the reward CS. It might be that the neutral CS functioned as a safety cue, signaling the absence of pain. Therefore, it is possible that differences in the salience and valence of the outcomes may be an alternative explanation for our findings. Additionally, the principle of regulatory anticipation, differences in fear acquisition pathways as compared to Part I—a reliance on inferences based on verbal information rather than direct experience—, perceived probability, and perceived controllability may be viable explanations for our findings. Furthermore, when participants were given a choice which movement to perform, presenting two incongruent cues—that is, the

reward and the pain CS—resulted in longer decision times, and more switching between performing the painful and the reward movement, a finding that is in line with literature demonstrating that decisions with value differences result in increased response latencies (e.g., Murray, 1975). In **Experiment III.2**, we wished to investigate the impact of environmental cues on free operant (avoidance) behavior, instead of pain-related fear and choices as indices of avoidance behavior. CSs associated with either pain, reward, or neither of both were integrated in the movement paradigm, in which participants could freely move a pneumatic robot arm in three different areas (represented by gates), associated with 80%, 50%, and 0% of painful stimulation, respectively. As opposed to our hypothesis and the findings of Experiment III.1, we found that participants appeared *less avoidant* when the *pain* CS was presented compared to when the reward or neutral CS was presented, although overall, participants still chose to move most often in the safe area. Alternative explanations may be available for these seemingly contra-intuitive findings. First, it is possible that pain cues only increase avoidance behavior for a subset of individuals, that is, individuals prioritizing pain avoidance; individuals prioritizing task completion or reward may choose to perform painful movements, because these movements help progression towards their (task completion) goal. Second, our study was one of the first to explore the effects of environmental cues in a context where pain can both be actively approached as well as avoided. It is possible that the CS functioned as a reminder cue to select a certain action, irrespective of the associated outcome. Third, there may have been an imbalance in the valence of the cues, as well as a difference in perceived probability. Fourth, from an expectancy-based framework (Dickinson & Balleine, 1994), the expectation of pain as a consequence of the presentation of the pain cue may have resulted in perceived uncontrollability.

Part IV: A systematic examination of goal conflict in chronic pain patients

When individuals are being confronted with a chronic illness, one of the main challenges they face is to manage living with this condition and its consequences. As such, it is possible that chronic pain patients often experience goal conflict between avoiding or controlling their pain and other life goals (Boudreaux & Ozer, 2012; Crombez et al., 2012). It has been clinically advocated to study goal competition and the solution of goal conflict in patients. However, research on the presence of these conflicts in clinical populations is lacking. Indeed, little is known about the actual experience of goal conflicts in chronic patients. To fill up this gap in literature, **study IV.1** explored the presence of goal conflict and its consequences in patients with fibromyalgia. For this purpose, participants completed a semi-structured interview. First participants reconstructed their day. Next, participants reported on the conflicts they experienced during the previous day. Subsequently, they classified each of their goals in one of nine pre-defined categories. Lastly, they assessed the experience of conflict as well as affect, pain and fatigue experienced during the previous day. In line with Karoly and colleagues (2008), we expected that patients with fibromyalgia would experience more goal conflict than control participants.Counter to expectactions, we observed that patients with fibromyalgia did on average not

experience more goal conflicts than control participants. However, when taking into account the type of goal conflict, patients reported more pain-related conflicts and less work-, social or pleasure-related conflicts than control participants. More specifically, for patients, pain goals most often conflicted with household, social and intrapersonal goals. These findings might be explained by contextual and individual characteristics, as our participants were mostly unemployed women, often receiving disability benefits. Furthermore, our sample was limited to patients seeking health care and thus may show different behavior and relations than patients functioning outside the health care system. Despite the fact that patients on average did not report more goal conflict, they did experience conflict as more aversive and as more difficult to solve. This again may be due to characteristics of the participant group. Furthermore, in line with the suggestion of Karoly and colleagues (2008) we expected that pain-related fear—and other core constructs of the Fear Avoidance model—would be associated with a higher number of goal conflicts. However, we could not discern these relationships in our study. We did however find that in the patient group, the number of pain-related conflicts could be predicted by the amount of cognitive intrusions and general anxiety levels. It might be that there was too little between subjects variability, or alternatively, goal conflict in chronic pain is related to the interpretation of a situation as catastrophic, fueled by cognitive intrusions and anxiety, rather than pain-related fear.

After the interview, the interviewer asked participants to complete a 'diary' for 14 consecutive days, in which they reported a conflict every time they experience one. At the end of each of day, participants were requested to fill in questions on their overall goal conflict experience and their day in general. The data analysis of this event-sampling procedure of the observational study are currently ongoing and are not reported in this dissertation.

Integrated discussion of the findings

Pain-related fear and avoidance behavior: two peas in one pod?

This project focused on the impact of goal competition on both pain-related fear and avoidance behavior as there is a wealth of evidence identifying them as two of the main components contributing to the maintenance and exacerbation of chronic pain problems (Leeuw, Goossens, et al., 2007; Lethem et al., 1983; Vlaeyen & Linton, 2012). In our experiments, we measured verbal fear responses and avoidance behavior, which is often regarded the behavioral component of pain-related fear (Lang, 1985). These two response systems are considered to be relatively independent, but may also affect each other (Lang, 1968). Indeed, several theories—such as the Fear-Avoidance model—propose that fear evokes avoidance behavior, although the opposite has been demonstrated as well (Gangemi, Mancini, & Van Den Hout, 2012). We assumed that goal competition would similarly affect pain-related fear and avoidance, and thus expected convergence for both variables. For example, we theorized that a concurrent reward would diminish pain-related fear and avoidance compared to a

situation without reward, and we expected that this avoidance-approach competition would evoke more fear than approach-approach competition, but less fear than avoidance-avoidance competition. Likewise, we expected more avoidance behavior to arise when confronted with the latter competition type compared to avoidance-approach competition. Our results however showed that the inclusion of reward or goal competition did not necessarily affect pain-related fear and avoidance behavior in the same way, nor do the different measurements for pain-related fear and avoidance behavior converge.

First, study I.1 demonstrated that pain-related fear did not predict avoidance behavior when accounting for motivation. In a backward regression analysis with pain-related fear, the importance of pain-avoidance and reward-seeking as predictors, pain-related fear was removed from the model, as it did not explain little to none of the variance in avoidance behavior. As such, it may be posited that fear is not a prerequisite in the alteration of (avoidance) behavior, and is in line with more cognitive theories of avoidance behavior, such as that of Seligman and Johnston (1973)—and opposed to Mowrer's Two-Factor Theory (1947; 1951)—as well as earlier studies in the field of pain (Van Damme et al., 2012). Clinical observations also indicate that even when fear is at a high level, people might still engage in the to-be-avoided activity if motivation is high. Hanna (the example described in the introduction) for instance, was highly motivated to spend quality time with her husband, despite indicating that she fears pain exacerbation.

Second, we found that a concurrent reward indeed attenuated avoidance behavior, but contrary to our initial hypothesis, fear remained unaltered. We however did not replicate this finding, as both pain-related fear and avoidance behavior differed depending on the competition type or context cue. Furthermore, the different studies did not always find similar data patterns for the same measurement.

Although there is disconcordance between and within response systems in our studies, and the observable responses/behavior seem to be best described as a "*loosely connected conglomerate of responses*", this not necessarily means that the underlying construct is amorphous (Crombez, Baeyens, & Eelen, 1993, p. 169). More specifically, these authors argue that the observable responses to pain may be the result of strategic and tactical components: strategic processes evaluate stimuli or events and guides behavior in a certain direction—in the case of a painful and aversive stimulus, typically avoidance—, whereas the tactical component refers to the adaptability of behavior to the needs of the environment (Crombez et al., 1993). Therefore, which specific pain responses arise is in essence determined by a multitude of factors, such as nociceptive information and the context.

In the following sections, we go into further detail on how both pain-related fear and avoidance behavior are affected by goals/goal competition and discuss possible explanations for our findings.

Goal competition and pain-related fear

Pain-related fear, measured using self-reports, was one of the major outcome variables in the experimental studies of this project.

In Part I, we found that differential fear responding was similar for a painful movement presented with concurrent reward versus without reward. However, when directly comparing movements associated with pain and reward to movements associated with pain alone in a context of multiple competition types (Part II), we found that a movement associated with both pain and reward resulted in *less* pain-related fear compared to a movement only associated with pain. The non-alteration of pain-related fear was somewhat surprising, as we expected a diminution of fear following the presentation of reward. We would like to point out that the expected decrease may be considered 'risky' (see Karoly, 2015), since cross-sectional studies have demonstrated that the presence of goal competition—such as the competition between a positive and a negative outcome—installed *more* fear than the absence of conflict (Karoly & Ruehlman, 1996). Others however have posited that presenting a concurrent reward alters the valence of a painful movement, and as a consequence, may result in a diminution of fear for the painful movement (e.g., counter conditioning; Raes & De Raedt, 2012). However, these authors found that presenting a reward with a CS that was previously paired with a pain-US did not result in fear reduction, and only a tendency to reduce skin conductance reactivity (Raes & De Raedt, 2012). Recently, another study in our lab—with as main objective to compare counterconditioning and extinction as a method of fear reduction—also found that concurrently presenting a reward did not attenuate pain-related fear (Meulders, Karsdorp, Claes, & Vlaeyen, 2015).

But why is it that pain-related fear remained unaffected by a concurrent reward in some studies, whereas it decreased in other studies? Or put otherwise: why did approach-avoidance competition compared to the absence of competition not lead to an alteration of fear in some of the studies, but did in others? One viable explanation may be that there were vital differences in the context of the experiment, as well as in the learning history of those participants. Previous research shows that a person's learning history affects fear and avoidance—at least, when testing the extinction of fear—and directly influences anxiety (Bouton & Bolles, 1979; Field, 2006; Stewart et al., 2001). More specifically, in study I.1 and I.2, the pain and reward outcome were always presented simultaneously—at least in the experimental condition—and participants thus could directly learn to associate the movement with *both* outcomes. Moreover, the test was reinforced, and took place in the same movement environment as the acquisition phase; in study II.1, however, participants completed two separate acquisition phases: one to learn about pain and safety; another to learn about reward and loss of reward. In the test phase, participants were informed that a movement could predict both outcomes. Moreover, our hypotheses were tested without explicit administration of either of the outcomes, and in an environment that was slightly different from both training phases: all 8

movements could be performed, whereas in each of the acquisition phases, only 6 could be performed. Therefore, it may be argued that these studies rely on different fear acquisition pathways: fear is acquired via direct experience in the former studies, whereas in the latter studies, fear is primarily acquired via inferences about the relations between movements and outcomes based on verbal information. Although the three main separate pathways to fear acquisition—that is, direct experience, observational learning, and verbal information—have been shown to lead to similar fear acquisition effects (Olsson & Phelps, 2004), it is unclear how combinations of learning impact on fear, or how it is affected by the addition of reward. Furthermore, the reinforcement and test environment during the test phase may have contributed to a more stable pattern of responding in the former studies, whereas the non-reinforcement and the complexity/novelty of the test environment in the latter studies may have left more room for changes in expectancies, and as a consequence, fear. In other words, it is possible that for study II.1, what was learned in the acquisition phases did not generalize to the test context. However, note that addressing the difference in fear responding between a painful movement with and without a reward was not the primary aim of study II.1, and that differences in fear levels between both variables were rather small.

In this project, we went beyond the study of one type of competition (concurrent reward versus pain) versus the absence thereof, and studied the impact of *several goal competition types* on pain-related fear. We found that pain-related fear was highest for competition involving two negative outcomes (pain and loss of reward), followed by competition between pain and reward, competition between safety and loss of reward, and was the least for competition involving two positive outcomes. These findings thus demonstrate that the type of competition influences the amount of fear reported. When taking a closer look, it seems that pain-related fear was mainly affected by the prospect or expectation of pain, and was further modulated by the prospect of loss, since competition types involving a painful outcome evoked more fear than competition types involving safety; and when comparing pain and loss of reward to pain and reward, the former evoked more fear than the latter.[4]

Although in line with our predictions based on conflict literature (Miller, 1944; Murray, 1975), some explanatory mechanisms need to be taken into account, aside from a hedonic principle. One possible explanation might lie in the value of the outcomes involved in the current project. Although we consider the outcomes equivalent (that is, safety and winning lottery tickets are both considered positive, whereas pain and losing lottery tickets are both considered negative), they might each correspond with different emotional responses (Gray, 1975; Mowrer, 1960). For example, inducing pain may cause fear, whereas loss of reward may result in disappointment. It is possible that our results may be explained by a possible inequality of the valence of the several outcomes, despite our

[4] Note that for 'eagerness', we found a similar, yet opposite pattern: the prospect of reward is the primary predictor of eagerness, whereas it is further predicted by the absence of pain.

best efforts. Previous research has indicated that secondary reinforcers such as monetary reward and the loss thereof can be as effective as primary reinforcers such as pain in fear conditioning, especially when fear is measured using self-reports (Delgado, Labouliere, & Phelps, 2006). However, the effectiveness of primary and secondary reinforcers differed depending on the context. Also, although both negative outcomes signal 'loss', the presence of pain and loss of reward might reflect two fundamentally different types of loss—excitatory and inhibitory, respectively—as is evident from the different brain systems that are recruited (Seymour, Maruyama, & De Martino, 2015). Furthermore, it seems that in our experiments, especially the 'safety'-outcome may have had a different quality compared to our other outcomes, as it was operationalized as not receiving any stimulation, nor reward or the loss thereof.

Another possible explanation for our findings might lie in individual differences in the perceived probability of each of the outcomes. Since the assumptions were tested in a non-reinforced environment, it is possible that participants generated their own ideas of the possibility of receiving each of the outcomes, despite having had the same training. Related to the previous points, Higgins (1997, p. 1293) proposed to consider regulatory anticipation—that is, approaching anticipated, hoped-for desired end-states and avoiding feared, undesired end-states—as a possible explanatory mechanism. This proposition fits well within the idea that pain-related fear is an (often excessive) *anticipatory* response when pain is expected (Kori et al., 1990). That anticipation or expectancy might play an important part in installing fear, was demonstrated by Mowrer, who found that human subjects displayed a significant galvanic stress response in anticipation of an electrocutaneous stimulus, which according to Lemov (2005) indicates that anticipation of pain might even be more aversive than the experience of pain itself. A similar proposition has been made with regard to pleasurable outcomes. Rozin (1999) for example suggested that anticipating rather than experiencing pleasure may be the cause of feelings of pleasure. The previously mentioned research of Delgado, Labouliere, and Phelps (2006) also suggests that *potential* monetary loss could be as aversive as anticipating pain. To explore the effects of inequality, expectancy and perceived probability of outcomes on pain-related fear, future research might want to install variation in the desirability of outcomes (e.g., using US re-evaluation; Baeyens et al., 1992; Walther et al., 2009) and in the probability of outcomes. Furthermore, future studies might benefit from including an expectancy measure to account for the possible role of expectancy when pain competes with other goals.

We also studied the impact of environmental cues installing competition, and found that a cue representing pain increased fear of movement-related pain for both a painful and a rewarding movement, and even decreased the eagerness of performing a rewarding movement. Again, one possible explanation for our findings, is the anticipation of pain and reward (regulatory anticipation; Higgins, 1997), even when they are predicted by cues that did not impact the to-be-executed behavior. In another experiment, focusing on the impact of environmental cues on avoidance behavior, we found

that participants were more afraid of a cue predicting pain than a movement associated with a similar chance of receiving pain and despite the fact that the painful stimulus was exactly the same. It is possible that participants perceived being able to choose movements and thus the movement itself as more controllable as compared to the presentation of cues. This perceived controllability is an important factor in motivational theories in understanding human behavior such as the accounts of Mineka and colleagues (Mineka & Hendersen, 1985; Mineka & Kihlstrom, 1978) or the theory of planned behavior (Ajzen, 1991); and loss of controllability is known to be associated with higher fear of pain (Crombez, Eccleston, De Vlieger, Van Damme, & De Clercq, 2008).

Goal competition and avoidance behavior

Next to pain-related fear, we studied the impact of goal competition on avoidance behavior in an experimental setting. As we indicated before, we expected the results of pain-related fear and avoidance behavior to converge, but this is not always the case. Furthermore, the behavior observed was dependent on the context in which it was studied. When a movement predicted both pain and reward, or when a painful movement was accompanied by a cue predicting reward (or vice versa), avoidance behavior operationalized as performing or a willingness to perform a (painful) movement was attenuated compared to when no competing cue or outcome was presented.

When taking into account different types of goal competition, we observed that avoidance-approach competition resulted in less avoidance behavior than avoidance-avoidance competition—whether it was caused by another negative outcome such as loss of reward accompanying pain or the addition of a cue predicting pain—and more avoidance than approach-avoidance competition (safety – loss of reward), no competition (pain only) or approach-approach competition (safety – reward). These findings are in line with earlier research on goal conflict predicting a similar pattern of results (Lewin, 1935; Miller, 1944; Murray, 1975), but again go against the idea that competition evokes more fear than the absence of competition (Karoly & Ruehlman, 1996). As with fear, mechanisms that might explain our findings are regulatory anticipation or the valuation and perceived probability of the outcomes (cf. supra).

However, when we studied the impact of cues predicting pain, reward, or neither of both (or simply, the absence of cues) on the behavioral choices participants made—that is a choice between a painful and a reward movement or the performance of a movement associated with a chance of 80%, 50% and 0% chance of stimulation, respectively—we find a somewhat inconsistent pattern of responding. First, we found that when participants could choose between the painful and the reward movement presented with their incongruent cue, participants selected the painful movement more often than when presented with any other combination of cues/movements. Furthermore, we found that participants chose to perform the most painful movement more often when a cue predicting pain

was presented, whereas cues predicting reward or none of both outcomes were associated with similar—lower—levels of avoidance behavior than not presenting a cue at all.

Although these results may seem contradictory, they can be explained from a motivational framework taking into account the type of goal competition. First of all, our findings overall demonstrate that cues are capable of installing competition, even though they only represent a goal. It indeed seems that avoidant decision making dynamically depends on the context (Crombez et al., 2012; Leeuw, Goossens, et al., 2007; Vlaeyen et al., 2009), rather than being a stable response (Hasenbring et al., 2009; Hasenbring & Verbunt, 2010). In a situation where both response options are combined with a cue incongruent to what they predict, this creates a double approach-avoidance competition. Double approach-avoidance conflicts are associated with choices between two options that both have costs and benefits, and often result in ambitendencies and oscillatory responding (Miller, 1944; Murray, 1975). Indeed, it seems that the more frequent selection of the painful movement in Study III.1 is caused by an oscillation between both response options, rather than simply reflecting less avoidant responding. This might however not fully explain the finding that a pain cue decreases avoidance behavior in study III.2. Alternatively, it is possible that these cues install competition that differs in perceived control (over pain). Perceived controllability over pain is an important factor in pain processing, perception and responding (Bandura & Wood, 1989; Crombez et al., 2008; Wiech et al., 2006). More specifically, it is possible that the presentation of a pain cue induced the idea that pain was uncontrollable—that is "I am getting pain anyway"—and participants thus select the response that was most efficient for completing the task. On the one hand, it is possible that the "diminished" avoidance reflects persistent cognitive, affective, and motivational deficits as a consequence of the perceived uncontrollability of pain (cf. learned helplessness; Abramson, Seligman, & Teasdale, 1978; Seligman, 1972). On the other hand however, it is possible that the diminished avoidant response is actually an adaptive response, as attempting to control uncontrollable pain is known to be associated with negative health outcomes as well as retarded performance (Crombez et al., 2008). At the least, these findings demonstrate that cues associated with pain are capable of interfering with other activities (Gandhi et al., 2013; Notebaert et al., 2011), although the interruptive qualities of pain might deserve more scientific attention.

For response latency, only one study observed that time needed to initiate a movement declined when a reward coincided with the painful stimulation, whereas in all other studies, no effect of reward emerged. This non-replication may be due to the fact that in the former study, participants were able to prepare and assess the to-be-performed movement prior to actual performance of the movement, whereas in the latter experiments, the experimental set-up no longer allowed for such preparation. Previous research indeed shows that being able to prepare modulates the effect of a monetary incentive on reaction time measures (Mir et al., 2011).

To summarize, we have proposed the following alternative hypotheses and explanations for our findings: We expected that the addition of a concurrent reward would alter the valence of a painful movement, and as a result, would diminish fear. Although advocated by learning theories, experimental research often reported non-alteration of fear. Furthermore, research in pain patients has shown that the experience of conflict (the addition of reward) results in an increase in fear. Differences in the (non-)alteration of fear in the several experimental studies can be explained by the hedonic principle, but alternatively by (1) differences in context or task characteristics; (2) differences in fear acquisition pathways: Part I may focus more on direct experience, whereas part II and III rely more on inferences made based on verbal information; (3) Differences in learning history; (4) regulatory anticipation; (5) perceived probability; (6) inequality in the valence and salience of stimuli or outcomes; and (7) perceived controllability. Similarly, the differences in the alteration of avoidance behavior may be explained by these principles. Moreover, the seemingly contradictory findings of Study III.2 may additionally be explained by (1) group characteristics; more specifically, it is possible that our hypothesis that pain cues lead to an increase in avoidance behavior only holds for individuals prioritizing pain avoidance; (2) the CS functioning as a reminder cue; and (3) Expectancy-based uncontrollability. Also, the non-replication of the attenuation of response latencies may be due to the possibility to prepare.

Goal competition and conflict strength

As indicated in the introduction, multiple goals may *compete* for similar resources, or may be associated with incompatible responses, leading to goal interference (Boudreaux & Ozer, 2012; Riediger, 2007; Riediger & Freund, 2004). Experiencing goal conflict can be characterized as the presence of two simultaneous forces of approximately equal yet opposite strength guiding behavior (Lewin, 1935). How strongly people experience goal conflict, thus might critically depend on the extent they consider the acting forces as equal in strength, and as a result may vary from situation to situation and between individuals. Typically, experiencing conflict results in "conflict behavior", characterized by oscillatory behavior patterns (as described above), but also an indecisiveness (Schrooten & Vlaeyen, 2010).

In our experiments, choice latency—the time between presentation of the conflict and response selection—serves as an index of this indecisiveness, reflecting how difficult it is to solve a particular conflict (Diederich, 2003; Houston, Sherman, & Baker, 1991; Murray, 1975). It is known that choice latency[5] depends on the number of choice options/stimuli involved: the more options, the longer it takes to solve the conflict (Broadbent, 1971). For example, we found that when participants needed to integrate multiple elements, that is, the information of simultaneously presented cues, it took them longer to make a decision than when no such cues were presented (Study III.1). Additionally we

[5] In literature often referred to as "decision time"

found that being presented with incongruent CSs, creating a double approach-avoidance conflict, slowed down decision-making as well, compared to congruent CSs. In Study II.1, we kept the choice options constant between trial types, that is, each response option was associated with two outcomes, allowing us to assess whether different types of goal competition are experienced more strongly than others. In line with previous research (Lewin, 1935; Miller, 1944; Murray, 1975), we found that avoidance-avoidance conflicts—or choosing between two negative outcomes—was solved more slowly than approach-approach conflicts. Although approach-avoidance conflicts were intermediate in choice latency, they did not significantly differ in choice latency from approach-approach conflicts.

Individual characteristics, goal prioritization and their modulatory effects on pain-related fear and avoidance

Throughout this project, several individual characteristics such as pain-related fear, catastrophizing, BIS/BAS, positive and negative affect, as well as idiosyncratic goal measures, such as goal importance and goal prioritization were included to uncover if certain individuals are more prone to experience pain-related fear or display more avoidance behavior in the face of goal competition in a context of pain.

In the experimental studies, none of the questionnaires assessing individual characteristics modulated the experience of pain-related fear and avoidance behavior. It is possible that, since the majority of participants were healthy, female students, there was too little variance in the scores to discern these relationships. Future studies might want to recruit from a broader population to include more variance in the sample.

For our goal measures on the other hand, several trends could be discerned. First, we found that the importance of the included goals—pain-avoidance and obtaining a reward—could reliably predict avoidance behavior. The modulation of defensive responding by goal prioritization however was not consistent. We found that when confronted with pain and reward (versus safety), the prioritized goal modulated avoidance behavior, with participants preferring pain-avoidance over reward-seeking choosing to avoid the painful more often more often than participants preferring reward-seeking or neither of both (study I.2), but this difference was not present in other studies. Additional analyses pointed out that pain-avoiders were less *eager* to perform a movement associated with pain when the same movement also predicted reward or when a Pavlovian cue predicting reward was presented. In study II.1 we found that pain-avoiders more often preferred loss of reward over pain compared to other groups when presented with an avoidance-avoidance competition. In studies II.1 and III.1 we found no differences between groups with regard to avoidant behavior as opposed to the finding that pain-avoiders engage in more avoidant behavior when a pain CS is presented compared to other groups (study III.2). However, caution is warranted to generalize these preliminary results to a

more general or clinical population, since in most of our studies, the groups are unbalanced and have insufficient power. Further scientific scrutiny is needed to assess the modulatory effect of goal prioritization on pain responding when confronted with competing goals.

Nonetheless, these results are informative, as they might instigate future research to further study the impact of goal prioritization in different types of goal competition on defensive fear responding. To make causal inferences, interesting avenues for further exploration might be to experimentally manipulate goal prioritization via verbal instructions (e.g., instructing one group to focus on avoiding pain as much as possible and disregard the reward, and another group to focus on gaining as much lottery tickets as possible) or re-evaluation of one of the outcomes (Baeyens et al., 1992).

Goal conflict in a clinical sample

In our observational study, we shifted focus from the study of goal competition on pain-related fear and avoidance to mapping the presence and experience of goal conflict in a population of patients with fibromyalgia compared to healthy individuals. First, although we expected patients to experience more goal conflicts than controls, we found no such difference. There were however clear differences in the type of goal conflicts participants reported: patients reported more pain-related goal conflicts, but less social, pleasure and work-related goals than control participants. Not unsurprisingly, it seems that when being confronted with chronic pain, goals involving pain control and avoidance take a more prominent place, whereas other activities are pushed to the background. Although we cannot pinpoint how often activities focused on pain control/avoidance take priority over other activities, from our experience during the interview, we would argue that the majority of patients prioritize pain, though intra-individual and interindividual differences exist, as demonstrated by Hanna (cf. introduction).

Our research was one of the first demonstrating the difference in how patients with fibromyalgia and healthy individuals experience conflicts. More specifically, patients reported more difficulty to solve their conflicts, it took them longer to solve conflicts, and they were less satisfied with how their conflicts were solved. Furthermore, they felt more stress, needed more support, reported more negative and less positive feelings, and worried more. Limitations in resources may contribute to this difference in experience. Indeed, suffering from a chronic condition such as fibromyalgia may impose both physical and cognitive constraints (Affleck et al., 2001). Additionally, it may be that socio-economical conditions such as poverty—that may or may not be due to their illness—may (further) limit resources when dealing with conflicting goals (Spears, 2011). However, as our results show no additional effect of the number of conflicts experienced, the underlying mechanisms may not be as simple. Another explanation for these (intra)individual differences in affective experience of conflict might lie in the extent of motivation with which individuals pursue goals (self-concordance). Gorges, Esdar, and Wild (2014) showed that when both competing goals of

a conflict are high on self-concordance, these conflicts are associated with positive affect, whereas low self-concordance is associated with negative. Following these authors, it may be fruitful to consider more goal properties to inquire what may cause these differences in conflict experience.

Additionally, our observational study further revealed that patients with fibromyalgia well-being is more negative than the well-being of healthy individuals. However, experiencing goal conflict did not have an impact on well-being, which is in line with Segerstrom and Solberg Nes (2006), but contradicts with studies that found a detrimental effect of goal-conflict (Boudreaux & Ozer, 2012; Emmons, 1986; Riediger & Freund, 2004). It has been suggested that goal conflicts at different levels of construal might affect well-being differently (Carver & Scheier, 1982). This might be a possible explanation for our findings, as we construed goal conflict by focusing on concrete, daily goals and activities (e.g., "help out Mary"), rather than more abstract, higher-order goals (e.g., "be a helpful person"). We did however find that in both groups, the higher the number of goal conflicts, the more people felt fatigued and the more they felt hampered by fatigue. Furthermore, the more goal conflicts pain patients experienced, the more they felt hampered by and ruminated about pain. However, the relationship may be the other way around, as our findings are correlation in nature. Hardy and colleagues (2011) for example found that women with fibromyalgia with higher average fatigue in the morning experienced more (objective) goal conflict.

Lastly, we included questionnaires assessing individual characteristics and core constructs of the Fear-Avoidance model, such as pain-related fear, catastrophizing, anxiety, and cognitive intrusions to investigate whether these characteristics could predict the number of conflicts experienced by both control and patient participants. We only found that in the patient group, cognitive intrusions and general anxiety were associated with a higher number of pain-related goal conflicts. As our sample was relatively small, future research might study these relationships in a broader sample.

Theoretical implications: expansion of the Fear-Avoidance model

As pointed out in the introduction of this dissertation, the current project focused on studying the dynamic relationships between goals, pain-related fear and avoidance behavior within a motivational framework (Crombez et al., 2012). Current Fear-Avoidance models have difficulties explaining how avoidance behavior may depend on contextual and motivational factors, such as personally relevant and valued goals (Crombez et al., 2012). Indeed, the extent to which an individual resorts to avoidance behavior is affected by the motivational context in which it takes place. Hanna for example, prefers staying at home over going out with friends, but at the same time chooses quality time with her husband over staying at home to prevent further harm.

The current project corroborates the expansion of the Fear-Avoidance model with a motivational perspective, as we demonstrated that avoidance behavior is not a stable response driven

by a fear-based motivation to avoid harm, but a dynamic response influenced by the context in which it is embedded (Crombez et al., 2012; Leeuw, Goossens, et al., 2007; Vlaeyen et al., 2009). Our results indeed provide experimental evidence that goal competition can influence pain behavior such as avoidance–although not always consistently. Overall, our findings suggest that avoidance behavior—or in general, the activities we pursue—may vary within individuals, depending on the situation. As a consequence, the "confrontation" and "avoidance" pathways in the Fear-Avoidance model may be better conceptualized as responses to specific situations. More specifically, we could argue that when experiencing pain, the goal to avoid (further) harm is activated along with other goals, such as staying fit or having drinks with friends. When a situation arises where pain interferes with the attainment of these other life goals, an individual basically has two options[6]: prioritizing the other life goal over pain avoidance ("confrontation"), such as for example going to the gym to stay fit; or prioritizing pain-avoidance over the pursuit of other life goals, where the individual stays at home watching TV to avoid pain exacerbation.

Although this project has done some groundwork to increase our understanding, more insight is needed into the mechanisms underlying the motivational influence on (persistent) avoidance behavior. For example, a motivational account of chronic pain problems may also help explain persistence and overuse, two phenomena often observed in patients with chronic pain (Vlaeyen & Morley, 2004). More specifically, patients may be motivated to stay committed to an activity or life goal, while ignoring pain (persistence). When this commitment to a goal is disproportionate (overuse), this may even have detrimental consequences for daily functioning and health status (Hasenbring & Verbunt, 2010; Lauwerier et al., 2012). One important note has to be made when studying motivational impact on behavior: an action may be considered instigated by "avoidance motivation" and as such, reflect avoidance behavior, but at the same time this action may help the individual attain another goal. For example, reading a book instead of going out with friends may be perceived as prioritizing pain avoidance over social goals, but can also be a choice for intrapersonal growth, as reading a book helps the individual gather knowledge. Future scientific endeavors might wish to incorporate both approach and avoidance goals, or to study both goal interference and facilitation to better understand the influence of motivational context on pain responding.

[6] For simplicity, we ignore the fact that individuals may also avoid the conflict itself and do not engage in either of the activities involved, since this response was never reported in our interview study.

Clinical implications

The findings presented in this dissertation may have some implications for clinical practice, although caution is warranted in generalizing our experimental findings to a general or clinical population.

Overall, our studies provide experimental support that cognitive-behavioral treatments of chronic pain that incorporate the pursuit of valuable daily life goals, instead of focusing solely on pain reduction goals may be more effective in improving daily functioning (Christiansen et al., 2010; Crombez et al., 2012; Schrooten & Vlaeyen, 2010; Schrooten, Vlaeyen, et al., 2012; Van Damme et al., 2008; Vlaeyen et al., 2009). As outlined in the introduction, several such interventions exist already, such as motivational interviewing, Acceptance and Commitment Therapy, Exposure in Vivo, and graded activity (Jensen et al., 2003; Jones et al., 2004; McCracken et al., 2007; Schrooten, Vlaeyen et al., 2012; Vowles & McCracken, 2008).

Identification and assessment of goals patients value aside from pain control or avoidance may prove a very valuable first step in enhancing general functioning despite pain, as it may also help us gain insight as to why individuals prioritize pain or engage in avoidance behavior. Whilst interviewing patients with fibromyalgia, we often heard them say they experienced goal conflicts between activities aimed at pain control or pain reduction such as resting or watching TV and other activities they need or want to do, such as cleaning the house or visiting a friend. Regularly, it resulted in pursuing the activity aimed at pain control, abandoning the other activity. What was also very striking during the interviews, was that even when the activities were not aimed at pain reduction or control, some patients chose the activity in function of the anticipated or expected pain; that is, when evaluating the costs and benefits for each of the activities, the amount of (expected) pain was a major component, tipping the scale in favor of the activity associated with the lowest level of (anticipated) pain. Moreover, although they experienced it as a conflict between activities, some of the patients reported they felt like they had *no choice*: they *had* to rest, they *had* to wait a little bit longer before getting up, they *had* to do [activity], because of pain, often emphasizing how much they miss doing things they previously loved. In this respect, treatments focusing on increasing flexibility when pursuing goals, such as Motivational interviewing (Ang et al., 2007; Jones et al., 2004; Miller & Rollnick, 2002) might be particularly valuable in motivating patients to pursue the valued activities despite pain, as they often start with exploring benefits and costs of all activities, and go beyond pain reduction only. As we experienced when interviewing patients, patients often heavily emphasize the burden of pain. Treatments for chronic pain might benefit from employing US revaluation strategies to reduce the importance of pain as an obstacle for pursuing other activities whilst increasing the value of these ‘rewarding’ activities (Field, 2006). Indeed, our experimental studies suggest that pain avoidance can

be overcome by competitive, valuable rewards, even when they identify pain avoidance as their most important goal.

Furthermore, more insight is needed in what type of conflict impairs daily functioning the most. One of our experimental studies pointed out that participants were most of afraid when feeling hemmed in between two negative options. We got a similar impression while conducting the interview: when patients focused on the negative aspects of both activities in their report, they often seemed to feel more distressed, as well as less satisfied with how they solved their conflict. One helpful strategy in overcoming these negative feelings, might be to reframe the different options so they focus on gains or positive elements, instead of losses or negative elements (Tversky & Kahneman, 1981, 1986). This reframing might help patients re-assess their conflict as an "approach-approach" situation, rather than an "avoidance-avoidance" situation. Alternatively however, it might be best to tailor the intervention to the individuals' approach/avoidance motivation, as previous research has pointed out that presenting messages congruent with their motivational preference were more effective than incongruent messages (Sherman, Mann, & Updegraff, 2006).

To date, it remains unclear for whom focusing on daily life goals instead of solely focusing on pain reduction results increases daily functioning, or which conditions might contribute to recovered activity despite pain. Some patients may benefit more from treatment strategies incorporating motivation than others. Another aspect that warrants further scrutiny is identifying individuals who are more prone to feel more hampered by pain and consequently disengage from valued activities. Lastly, identifying contextual cues a as well as possible underlying mechanisms contributing to differences in behavior in a motivational context warrants scientific inquiry.

Strengths and limitations

A particular strength of this dissertation is the usage of both experimental and observational methods. Our more fundamental work with healthy subjects may help increase our understanding of the motivational impact on the experience of pain and corresponding responses, while our observational work with patients informed us on the presence of goal conflict in daily life, and may instigate further questions for experimental research. Next, we discuss strengths and limitations for the experimental and the observational research separately.

Experimental Research

A major strength of our experimental research is that it builds upon a well-established experimental design, that is, the Voluntary Joystick Movement paradigm (VJM; e.g., Meulders et al., 2011; Meulders & Vlaeyen, 2013b). The Voluntary Joystick Movement paradigm has proven to be a useful research tool to study the acquisition (and alteration) of fear and avoidance behavior, and since its first application, has been widely validated (e.g., Claes, Crombez, & Vlaeyen, 2015; Claes et al.,

2014; Meulders, Vansteenwegen, et al., 2012; Meulders & Vlaeyen, 2012; Meulders, Vervliet, et al., 2012; Volders et al., 2012). To quickly recapitulate, the Voluntary Joystick Movement paradigm uses movements as CSs and tolerable yet painful electrocutaneous stimuli as USs. Typically, a differential conditioning procedure is used, with one movement serving as a CS- and is never followed by the pain US, whereas another movement serves as a CS+ and is thus accompanied by the pain US. This set-up allows for differential comparisons. Furthermore, this paradigm is highly adaptable, making it an excellent means to study the impact of concurrent goals on pain-related fear and avoidance behavior. Recently, Meulders and colleagues (2016), created a (free) operant version of the VJM paradigm, in which participants operate a three-degrees pneumatic robot arm in a 2D-environment (see also Experiment III.2). Initial acquisition is not completely free—participants are required to perform all three movements a number of times, but are allowed to choose the order in which they perform movements—but test phases are "free", in the sense that participants are enabled to choose which movement they wish to perform. Furthermore, the haptic environment of the pneumatic robot arm creates an opportunity to study a wider range of movements, as well as force and effort exerted when performing movements.

However, the VJM paradigm also has its limitations, which also apply to our research, mostly pertaining to the generalizability and the ecological validity of the findings. First, the sample under investigation is often small in size and mostly consists of healthy undergraduate students. As a consequence, the translation of our experimental findings to a clinical setting is difficult and should be made cautiously. Second, the VJM paradigm typically uses a discrete, experimentally induced pain stimulus, set at pain tolerance. This differs from the experience of patients with chronic pain, who often report that pain is continuously present. In the VJM paradigm, fear of a painful US is installed, whereas patients mostly fear an increase in pain or higher-than-usual pain. To overcome this limitation, we could administer a tonic painful stimulus that is continuously present while an increase in stimulation or an additional discrete painful stimulus serve as USs, but this may prove ethically challenging. Alternatively, it may be fruitful to use this paradigm in a patient population suffering from chronic pain to increase ecological validity. Third, although the VJM paradigm allows for the study of movements, the movements participants were able to perform are restricted (e.g., only four movement options available). In our experiments, and contrary to the original VJM paradigm of Meulders and colleagues (2011), movements were sometimes not voluntary but "instructed", that is, a cue signaled which movement participants were requested to perform in initial acquisition phases. However, this operationalization allowed the experimenter to control the experimental environment and ensured contingency learning/awareness. The latter often is a prerequisite to make an adaptive response. This also reflects one of the strengths of our experimental work, that is, the incorporation of decision making as an index of avoidance behavior. In our studies, we operationalized avoidance behavior in general as *not* performing the (painful) movement, either by indicating whether or not they

will perform the movement or by (choosing to) perform(ing) an alternative movement that does not involve pain (e.g., safe movement or the reward movement). In our latest experimental study (study III.2), we not only had an indication of decision-making, but also an avoidance gradient based on the distance participants moved away from the most simple and simultaneously most painful movement (see also Meulders et al., 2016). This operationalization provides a novel way to study avoidance behavior, since it goes beyond a binary coding of behavior in "moving away from (avoidance)" or "moving towards (approach)" (see for example AAT tasks; De Houwer, Crombez, Baeyens, & Hermans, 2001; Krieglmeyer & Deutsch, 2010) and allows to study more subtle forms of avoidance behavior (Salkovskis, 1996). Operationalization of avoidance behavior as a choice however enables the use of mathematical models to study more specific choice parameters (Krypotos, Beckers, Kindt, & Wagenmakers, 2015). We elaborate on this point when discussing future directions.

Furthermore, in our studies, we systematically included self-reported and behavioral measures, to measure fear and avoidance behavior. However, none of our studies included psychophysiological measures. Future studies building on current project would benefit from including psychophysiological markers of pain-related fear, such as eye blink startle responses (Lang & McTeague, 2009), or markers of arousal, such as pupil dilatation (Bradley et al., 2008). However, note that these measurements may not necessarily correlate with each other, or with the self-reported and behavioral measures.

Another concern relates to the ecological validity of the outcomes used in the experimental studies. First, as we already discussed, the phasic administration of experimental pain does not correspond with the rather continuous feeling of pain patients report. Second, concerns might be raised about the use of lottery tickets as a competing positive outcome, although their success in installing approach motivation has been previously demonstrated in healthy subjects (e.g., Talmi et al., 2009; Van Damme et al., 2012). In clinical (patient) samples these rewards/lottery tickets may not be as successful. However, we believe that the use of lottery tickets resembles daily life situations, since patients often have to weigh a direct negative outcome (pain exacerbation) against a delayed positive outcome (e.g., a paycheck; Karoly, 2015). Furthermore, direct rewards are difficult to operationalize in a laboratory setting, and may lose some of their appetitive value after multiple presentations (e.g., candy, drinks). Moreover, aside from study I.1, lottery tickets represented a chance of winning a prize of the participants' own choice, which could be a monetary gain, but could also reflect more social, intrapersonal, or leisure goals (e.g., a donation to a good cause in their name, spa treatment, cinema tickets). This may be—according to us—a particular strength of our studies, since it takes into account individual preferences for rewards. Third, it could be argued that there is an imbalance in the chosen outcomes in study II.1. Aside from painful stimuli at tolerance level as a negative outcome and gaining 2 lottery tickets as a positive outcome, we also had two other outcome options: safety was defined as the absence of a painful stimulus and used as a positive outcome, whereas losing 1 lottery ticket served

as a negative outcome. Outcomes were selected based on the valuation of the outcome. According to this view, administration of a positive stimulus, omission or termination of an aversive stimulus are functionally equivalent and acquire a positive valence; whereas taking away or leaving out a positive stimulus, or presenting an aversive stimulus acquire negative valence (Diederich, 2003; Gray, 1975). Our operationalization of safety meant that participants did not receive anything—or received nothing, dependent on the point of view—which according to this view is as such a positive outcome as is the administration of reward, but in practice may be ambiguous. Furthermore, although we always referred to this outcome as "safety" in communicating with participants, future research may want to explore alternative ways to operationalize safety. One option may be to present a cue on screen that signals safety as an outcome. More specifically, one could present the pain CS with an additional cue signaling safety, to make the relation between pain and safety clearer (see also "occasion setting", Schmajuk & Holland, 1998). With regard to the negative outcome, we reasoned that the absence of reward would resemble the absence of a painful stimulus too much, which possibly could have hampered movement-outcome learning, especially when having to differentiate between these two outcomes, since they would both be associated with "nothing". Furthermore, prior to the study, we took the time to explore various options such as losing 2 lottery tickets, not receiving 2 lottery tickets, losing 1 lottery ticket, etc. and found that participants considered "not receiving 2 lottery tickets" as confusing, whereas "losing 2 lottery tickets" was considered too aversive and unfair. Losing 1 lottery tickets (as compared to winning 2 lottery tickets) best resembled the option of safety (as compared to the painful stimulus) in our pilot study. A limitation however is, that although these options may in general may be balanced, large individual differences may arise tipping the scale over in one direction. Furthermore, previous research has shown that (a) pain and loss of reward may reflect two fundamentally different types of loss, at least in the brain (Seymour et al., 2015); and (b) the price people are willing to pay for pain relief—or to translate it to our own research: the amount of lottery tickets participants were willing to lose in return for safety in the approach-avoidance conflicts—is context-dependent (Vlaev et al., 2009), something we did not account for in our experiments. Future research might benefit to account for these (individual) differences in valence, as well as the trade-off between two competing outcomes, irrespective of their valence.

Observational study

A merit of the clinical-observational study is the fairly structured way we could study the idiosyncratic experience of goal conflict by building on a validated method, the daily reconstruction method (Kahneman et al., 2004). We started from participants' experiences, by giving them the possibility to recall their conflicts of the previous day, as well as by having them classify each of their goals in one of the pre-defined categories themselves. A limitation is that this creates a less controlled environment, especially in the case of the event-sampling/end of day-diary: patients may have not spontaneously reported how pain interfered with other daily life goals, or even may have reported no

goal conflicts at all. Although this is informative in and of itself, this automatically also resulted in 'missing data', since in the case participants did not report conflict, no information on the experience of conflict could be collected. Similarly, based on piloting work, we decided a priori to only assess 3 conflicts if participants reported more than 3 conflicts during the interview, in order not to overexert them. This also resulted in minor data loss for 10 conflicts (out of 130, 7.6%). We would argue to assess all reported conflicts in the future. Another limitation, for both the participant and the researcher, is that the event-sampling procedure was time-consuming, especially considering that participants were requested to keep a paper 'diary' and noted down a conflict each time they experienced one, and at the end of the day were requested to fill in an online questionnaire about their conflicts as well as their day in general. First of all, the majority of participants that dropped-out of the event sampling study did so because they considered it too time-consuming (11 patients and 4 controls; 78.9% of all drop-outs). Second, it is possible that participants did not report on all conflicts to save time or because they only filled in their 'diary' at the end of the day.

Another limitation of the interview as a whole as well as the end-of-day diary, is that it was conducted retrospectively. These retrospective ratings may have been biased by how participants were feeling at the time of report, or simply based on what they remembered, as well as an attention bias towards more positive or negative experiences. To have more control, to have online measurements, and to reduce the time needed to complete the study, future research may consider the use of PDAs or smartphone applications in an event-sampling procedure, although this might install a selection bias in the sample.

Lastly, generalizability of the results of the observational studies to the general and clinical population is difficult. First of all, as is the case in our experimental studies, we tested a small number of participants, which results in limited power. Second, it is possible that a subset of patients with fibromyalgia participated in our research, for example, those who feel hampered by their pain and fatigue. Similarly, since control participants could subscribe for scientific research, it may be possible that we tested only a subset of control participants. Furthermore, we explicitly formulated that chronic illness was an exclusion criteria for control participants, which may not be a realistic feature of the population in general, especially not in people of older age.

Contributions of the presented research to the literature

This project focuses on the study of the impact of goal competition on pain-related fear and avoidance behavior. Models on goals and goal pursuit have a strong pedigree, and prominent researchers in the field of pain have argued that a fundamental feature of pain is its competitive nature. Nevertheless there are only a few experimental studies in the field of pain research. Most research within the field relies on questionnaire data—making inferences on cause-effect relationships

difficult—or focused mainly on the study of goal shielding and distracting attention away from pain. In the context of pain, there is little to no research investigating the impact of (pain-related) goal competition on pain-related fear and avoidance behavior. There is also no research on the nature of goals conflicts in pain patients, and their possible effects on daily life and well-being. The importance of the presented research lies in its contribution to our understanding of the impact of goal competition on pain-related responding, and may be important for the treatment of chronic pain problems as well, as it is in line with the (relatively novel) idea that the importance of goals and values should be incorporated in psychological treatments. Moreover, the presented research may serve as an important catalyst for further research to increase our understanding, and may lead to the extension of existing models tackling the inception, maintenance, and exacerbation of chronic pain problems in which avoidance and fear have a prominent role. As the project also focused on avoidance behavior—or avoidant decision-making—we tackled a highly neglected, yet highly relevant topic that may have implications outside pain research as well, as avoidance is a key component in other disorders as well.

The key findings of the presented research are: (1) concurrent rewards diminish avoidance behavior; (2) individual differences in goal prioritization modulate avoidant (decision-making) behavior; (3) being hemmed in by two negative outcomes (avoidance-avoidance competition) is associated with more pain-related fear and avoidance behavior; (4) response latency and choice difficulty increase if choices involve goal conflict; (5) Pain-related fear and (goal-directed) avoidance behavior are cue-controlled, that is, Pavlovian cues are capable of installing competition and altering behavior, albeit in different ways; and (6) although pain patients do not report more goal conflict, they experience different types of goal conflict, perceive goal conflict as more aversive, and have more difficulties in solving goal conflict than healthy participants.

Although some of these propositions may be well-established in the literature (outside the field of pain), the presented research is notable for the following innovations aside from its theory-based foundation: (1) Our experiments are among the first to address the recent call to further examine causal relationships between goal competition and defensive pain responding and rigorously and systematically test the implications of goal competition in pain in a well-controlled experimental environment using proprioceptive stimuli, that is the Voluntary Joystick Paradigm. This Paradigm allowed us to draw conclusions from both verbal responses and behavioral data (choice behavior, latencies); (2) Relatedly, the experimental design of Study III.2 provided a novel way of studying avoidance behavior. More specifically, we created an experimental environment in which the impact of cue-controlled avoidance behavior can be operationalized as a gradient instead of a binary response. Moreover, this design allows for comparison between active approach and active avoidance of painful movements, having possible benefits for research outside the field of pain as well; (3) We went beyond the study of only one goal, and included multiple goals by introducing both positive and negative outcomes in the face of pain, a topic that has received little attention; (4) We incorporated

individual's goal prioritization; and lastly (5) were the first to map the presence and type of goal conflict in a population of chronic pain patients, gaining more insight in the goal dynamics that arise in this population.

Given the novelty of the experimental design and the seemingly contradicting findings in some of the studies, further replication and expansion of these results and propositions are warranted."

Future directions

In this part of the dissertation, we explore some interesting avenues for future research.

First, despite the potential detrimental impact of avoidance behavior on daily functioning, the decision processes involved in avoidance behavior remain poorly understood (Krypotos, Effting et al., 2015; Volders et al., 2015). An interesting avenue to explore might be the trade-off between *exploring* an uncertain environment to potentially improve the current status—but with a risk of the situation becoming worse—or *exploiting* known actions to maintain the current status (Reverdy, Wilson, Holmes, & Leonard, 2012; Wilson, 1996). This "exploration-exploitation dilemma" has been a topic of scientific inquiry in psychology (Aston-Jones & Cohen, 2005), artificial intelligence (Cai, Liao, & Carin, 2009), neuroscience (Cohen, McClure, & Yu, 2007), and organizational and health economics (Adler et al., 2009), but has been mainly applied to approach behaviors and reward environments. Finding an optimal strategy to deal with aversive situations, such as being in pain, might also critically depend on balancing collection and exploitation of information. More specifically, uncovering when and how people decide to resort to avoidance (exploitation) or engage in activities to uncover whether a specific action is still the 'best option' to keep pain at a tolerable level (exploration) might help to increase our understanding of avoidance behavior.

Therefore, as stated earlier, it might be fruitful to use mathematical models to quantify several decision making parameters, since common analysis techniques—as used throughout this dissertation—do not directly measure the cognitive processes involved in decision-making, such as the speed of information accumulation (Krypotos, Beckers et al., 2015). One example of such a model is the Drift Diffusion Model (Ratcliff & McKoon, 2008; Ratcliff & Tuerlinckx, 2002; Ratcliff, 1978; Wagenmakers, 2009) that recently has been applied to AAT tasks (Krypotos, Beckers et al., 2015), perceptual decision-making in pain (Wiech et al., 2014), and has been proven helpful in increasing our understanding of decision processes in several areas of research (e.g., Cavanagh, Wiecki, Kochar, & Frank, 2014; Pe, Vandekerckhove, & Kuppens, 2013; Ratcliff & Tuerlinckx, 2002; Wiech et al., 2014). In short, the Drift diffusion model decomposes binary decisions—often "correct" and "incorrect"—into several cognitive/psychological processes, each represented by a different parameter. This model assumes that the decision process is characterized by noisy information accumulation that stops when a decision boundary—reflecting one of the two possible options—is

reached (Ratcliff & McKoon, 2008). More specifically, there are four main parameters reflecting the speed of information accumulation. The first parameter is starting point *z*, which reflects an a priori bias to one of both response options. The second parameter is the drift rate, *v*, mapping the efficiency of information accumulation. The third parameter is boundary separation, *a*, representing the required evidence in order to make a decision or response caution. Lastly, the fourth parameter is the non-decision time, comprising of motor execution. As suggested by other authors (e.g., Krypotos et al., 2014), the usage of these mathematical models may increase our understanding of avoidance behavior by decomposing it into different decision-making variables.

Second, and related to the previous point, patients with chronic pain often avoid certain movements or activities out of habit. One possible way a habit arises, is the repeated use of a particular behavioral means to attain a goal, such as staying at home to rest instead of going out to avoid further harm. Or put otherwise, they may be the residue of past goal pursuit (Wood & Neal, 2007, p. 844). An important distinction can be made between habits and more goal-directed action: habits are in general more susceptible to the (motivating) influence of context cues, and are often less sensitive to extinction procedures (De Wit & Dickinson, 2009; Holmes et al., 2010; Krypotos, Effting et al., 2015). Furthermore, it has been argued that a goal-directed action is instrumental, based upon knowledge that the action leads to a certain consequence (belief criterion), and that the outcome is desirable for the agent (desire criterion; De Wit & Dickinson, 2009). However, little is known about when goal-directed actions turn into habits. Understanding when this transition occurs, and which factors contribute to this transition, may prove helpful to prevent developing maladaptive habits or how to tackle them (Krypotos, Effting et al., 2015).

Third, under some conditions, goal conflict elicits an urge ‘to leave the field’ (Murray, 1975). Indeed, it seems that under some circumstances, people are inclined to escape the conflict itself. In our research, participants however had no opportunity to disengage. Future research might want to explore when and how often people tend to ‘leave the field’ when presented with different types of goal competition. One possibility is to add an ‘escape’-option to our experimental design that is available on a limited number of trials. This escape-option can be operationalized as including a safety button, which participants can press to temporarily suspend all reinforcement—both painful stimulation and (loss of) lottery tickets—, thus abating the conflict. One might expect that the safety button will be pressed more often when one movement represents an approach-avoidance competition compared to avoidance-avoidance or approach-approach competition; and that the safety button will be pressed more often when being hemmed in between two negative outcomes than between one positive and one negative or two positive outcomes.

Fourth, our project primarily focused on the impact of goal competition on pain-related fear and avoidance behavior. Another interesting avenue for research might be to investigate how the

experience of goal conflict impacts on pain sensitivity. More specifically, it would be interesting to uncover if pain sensitivity increases when pain interferes with valued goals. One possibility would be to apply our (VJM) paradigm in a between-subject design and collect self-reported measures and psychophysiological measures of pain sensitivity, such as the nociceptive flexion reflex (NFR; Rhudy & France, 2007) or the diffuse noxious inhibitory control (DNIC; Weissman-Fogel, Sprecher, & Pud, 2008). We hypothesize that being hemmed in between two negative outcomes (avoidance-avoidance; pain – loss of reward) would be associated with an increase in pain sensitivity as compared to other types of conflict or experiencing no conflict at all, and is mediated by fear of pain, since our own research demonstrated that avoidance-avoidance competition evokes more avoidance behavior and fear than the other types of conflict (study II.1), and since Hardy and colleagues (2011) found that goal conflict was associated with an increase in the experience of pain.

Lastly, in our observational study, we focused on the presence, type, and experience of goal conflict rather than how the goal conflict was solved. Future research might want to study how often patients choose to do the activity involving controlling or avoiding pain over other activities, whether the extent of conflict solution in favor of pain avoidance can be predicted by pain catastrophizing, pain-related fear or other individual characteristics, and whether it is associated with more impaired daily functioning and less satisfaction as compared to individuals who solve the conflict by favoring other activities over pain avoidance and control.

Conclusion

All in all, the current project provides experimental evidence for the impact of both pain avoidance and competing goals on avoidance behavior and decision-making. We have built on a well-established proprioceptive fear conditioning paradigm, and uncovered that concurrent rewards can attenuate avoidance behavior, an effect that is further modulated by goal prioritization; that cues may install goal competition; and that being hemmed in between two negative stimuli is especially detrimental for avoidance and decision-making. Our observational research in a pain patient sample on the other hand showed that patients with chronic pain not necessarily experience more conflict than healthy subjects, but their conflicts feature pain very prominently.

Taken together, the present project might instigate future research to study goal conflict, decision-making and avoidance, and can have implications for the cognitive-behavioral treatment of chronic pain.

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DATA STORAGE FACT SHEETS

Data Storage Fact Sheet Part I – Chapter I.1 (15/02/2016)

% Data Storage Fact Sheet version 15/02/2016
% Name/identifier study: **< PhD Nathalie Claes, Part I – Chapter I.1, concurrent reward attenuated avoidance behavior>**
% Author: Nathalie Claes
% Date: 15/02/2016

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If a response is not received when using the above contact details, please send an email to secr-og@ppw.kuleuven.be or contact the Secretariat Health Psychology, Tiensestraat 102 box 3726, 3000 Leuven.
Another possibility is to send an e-mail to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

* Reference of the publication in which the datasets are reported:

> Claes, N., Karos, K., Meulders, A., Crombez, G., & Vlaeyen, J. W. S. (2014). Competing Goals Attenuate Avoidance Behavior in the Context of Pain. *The Journal of Pain*, 15(11), 1120–9. doi:10.1016/j.jpain.2014.08.003
>
> Dissertation Nathalie Claes: Chapter I.1: Competing goals attenuate avoidance behavior, but not pain-related fear.

* Which datasets in that publication does this sheet apply to?:

> All datasets reported in this publication/chapter of the doctoral dissertation. All raw data was integrated in one "full" dataset, comprising of (1) output data from the experiment (self-reports, reaction time measurements); (2) questionnaire data; (3) HRV data. The latter is not reported in the publication or the dissertation.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [x] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

- [x] researcher PC
- [ ] research group file server
- [x] other (specify):

-Augias, The online research and data documentation platform of the research group Behavior, Health and Psychopathology of Leuven university, currently only accessible for registered users. The study is registered under the name "EXP1 Pain and non-pain goals attenuate avoidance behavior (Multitasking Study)". Augias contains an extensive description of the data and data-analysis.
-An external hard drive on which all raw and full data are stored.

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

- Co-authors: Kai Karos (kai.karos@ppw.kuleuven.be), Ann Meulders (ann.meulders@ppw.kuleuven.be)
-Programmers and administrators of Augias: Jeroen Clarysse (jeroen.clarysse@ppw.kuleuven.be) and Mathijs Franssen (mathijs.franssen@ppw.kuleuven.be)

3b. Other files

* Which other files have been stored?

- [x] file(s) describing the transition from raw data to reported results. Specify:

SPSS syntax files to transition from raw data to a data-file that can be used for analyses; SPSS syntax files to merge all data from different input channels (experiment data; questionnaire data); SPSS syntax files with descriptions of statistical operations such as calculation means etc.; SPSS syntax files for the main analyses of the results (see syntax.zip: analysis, data-preparation, HRV analysis, outliers_reaction times, and questionnaires – folders)

- [x] file(s) containing processed data. Specify:

SPSS data files containing the data
- raw data: raw_data.zip: raw experimental data (self-reported ratings and RTs)
- HRV data: HRV_raw.zip
-Processed datafile for analysis: complete dataset_processed.zip

- [x] file(s) containing analyses. Specify:

    SPSS output files containing the results of the study (see Results.zip)
    Summary document [this document is not available on Augias]

- [x] files(s) containing information about informed consent

    All study documents and the experiment itself, including informed consent, are stored on the individual PC of the main researcher and on an external hard drive.

- [x] a file specifying legal and ethical provisions

    The ethical committee approval is stored (S55216 N.Claes.pdf)

- [x] file(s) that describe the content of the stored files and how this content should be interpreted. Specify:

    Syntax files should provide an explanation of what each operation does in comments (indicated by "*"); in SPSS data-files (.sav), in the tab "variables", all original variable are provided with a label and an explanation of what the variable is

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [x] individual PC
- [ ] research group file server
- [x] other: external hard drive; Augias

* Who has direct access to these other files (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

    - Co-authors: Kai Karos & Ann Meulders
    -Programmers and administrators of Augias: Jeroen Clarysse and Mathijs Franssen

4. Reproduction

* Have the results been reproduced independently?: [x] YES / [ ] NO

* If yes, by whom (add if multiple):

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Data Storage Fact Sheet Part I – Chapter I.2 (15/02/2016)

% Data Storage Fact Sheet version 15/02/2016
% Name/identifier study: **< PhD Nathalie Claes, Part I – Chapter I.2, goal competition and goal prioritization >**
% Author: Nathalie Claes
% Date: 15/02/2016

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1c. Responsible Staff Member: Promotor KU Leuven (ZAP)

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If a response is not received when using the above contact details, please send an email to secr-og@ppw.kuleuven.be or contact the Secretariat Health Psychology, Tiensestraat 102 box 3726, 3000 Leuven.
Another possibility is to send an e-mail to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

* Reference of the publication in which the datasets are reported:

> Claes, N., Crombez, G., & Vlaeyen, J. W. S. (2015). Pain-avoidance versus reward-seeking: an experimental investigation. *PAIN*, *156*(8), 1449–1457. doi:10.1097/j.pain.0000000000000116
>
> PhD dissertation of Nathalie Claes: Chapter I.2: The Impact of goal competition and goal prioritization on avoidance behavior and pain-related fear

* Which datasets in that publication does this sheet apply to?:

> All datasets reported in this publication/chapter of the doctoral dissertation. All raw data was integrated in one "full" dataset, comprising of (1) output data from the experiment (self-reports, reaction time measurements); (2) questionnaire data; (3) HRV data. The latter is not reported in the publication or the dissertation.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [x] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

- [x] researcher PC
- [ ] research group file server
- [x] other (specify):

    -Augias, The online research and data documentation platform of the research group Behavior, Health and Psychopathology of Leuven university, currently only accessible for registered users, registered as "EXP2 The influence of competing pain and non-pain goals on defensive responding (multitasking study 2)". Augias contains an extensive description of the data and data-analysis.
    -An external hard drive on which all raw and full data are stored.

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

    -Programmers and administrators of Augias: Jeroen Clarysse (jeroen.clarysse@ppw.kuleuven.be) and Mathijs Franssen (mathijs.franssen@ppw.kuleuven.be)

3b. Other files

* Which other files have been stored?

- [x] file(s) describing the transition from raw data to reported results. Specify:

    SPSS syntax files to transition from raw data to a data-file that can be used for analyses; SPSS syntax files to merge all data from different input channels (experiment data; questionnaire data); SPSS syntax files with descriptions of statistical operations such as calculation means etc.; SPSS syntax files for the main analyses of the results. See syntax.zip (containing several folders following the subdivisions described above)

- [x] file(s) containing processed data. Specify:

    SPSS data files containing the data:
    - raw experimental data: raw_data.zip (txt-files; excel-files)
    - questionnaire data: questionnaires.zip (excel & SPSS)
    - Processed data used for analysis: complete dataset.zip (SPSS & Excel)

- [x] file(s) containing analyses. Specify:

    SPSS output files containing the results of the study (Results.zip)

- [x] files(s) containing information about informed consent

    All study documents and the experiment itself, including informed consent, are stored on the individual PC of the main researcher and on an external hard drive.

- [x] a file specifying legal and ethical provisions

    The ethical committee approval is stored (S-55669 Claes.docx)

- [x] file(s) that describe the content of the stored files and how this content should be interpreted. Specify:

    Syntax files should provide an explanation of what each operation does in comments (indicated by "*"); in SPSS data-files (.sav), in the tab "variables", all original variable are provided with a label and an explanation of what the variable is

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [x] individual PC
- [ ] research group file server
- [x] other: external hard drive; Augias

* Who has direct access to these other files (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
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4. Reproduction

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* If yes, by whom (add if multiple):

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Data Storage Fact Sheet Part II – Chapter II.1 (15/02/2016)

% Data Storage Fact Sheet version 15/02/2016
% Name/identifier study: **< PhD Nathalie Claes, Part II – Chapter II.1 , various types of goal competition>**
% Author: Nathalie Claes
% Date: 15/02/2016

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If a response is not received when using the above contact details, please send an email to secr-og@ppw.kuleuven.be or contact the Secretariat Health Psychology, Tiensestraat 102 box 3726, 3000 Leuven.
Another possibility is to send an e-mail to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

* Reference of the publication in which the datasets are reported:

> Claes, N., Crombez, G., Meulders, A. & Vlaeyen, J. W. S. (in press). Between the devil and the deep blue sea: avoidance-avoidance competition increases pain-related fear and slows down decision-making. *Journal of Pain*. DOI: 10.1016/j.jpain.2015.12.005
>
> PhD dissertation Nathalie Claes: Chapter II.1 An experimental investigation of the differential effects of various types of goal competition on defensive responding

* Which datasets in that publication does this sheet apply to?:

> All datasets reported in this publication/chapter of the doctoral dissertation. All raw data was integrated in one "full" dataset, comprising of (1) output data from the experiment (self-reports, reaction time measurements); and (2) questionnaire data.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [x] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

- [x] researcher PC
- [ ] research group file server
- [x] other (specify):

-Augias, The online research and data documentation platform of the research group Behavior, Health and Psychopathology of Leuven university, currently only accessible for registered users. The experiment is registered as "EXP4 the impact of multiple goals on pain-related fear". Augias contains an extensive description of the data and data-analysis.
-An external hard drive on which all raw and full data are stored.

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
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-Programmers and administrators of Augias: Jeroen Clarysse (jeroen.clarysse@ppw.kuleuven.be) and Mathijs Franssen (mathijs.franssen@ppw.kuleuven.be)

3b. Other files

* Which other files have been stored?

- [x] file(s) describing the transition from raw data to reported results. Specify:

SPSS syntax files to transition from raw data to a data-file that can be used for analyses; SPSS syntax files to merge all data from different input channels (experiment data; questionnaire data); SPSS syntax files with descriptions of statistical operations such as calculation means etc.; SPSS syntax files for the main analyses of the results. A full description can be found in Datapreparation_EXP4.docx; the Syntax contains 2 files: Syntax_Descriptives.sps and Syntax_EXP4_main results.sps.

- [x] file(s) containing processed data. Specify:

SPSS data files containing the data:
- raw data can be found in the DATA.zip file
- the complete dataset (processed and ready to perform analysis is stored in complete_dataset_EXP4_calculated.sav

- [x] file(s) containing analyses. Specify:

    SPSS output files containing the results of the study:

    -EXP4_Descriptives_Final.spv: descriptive statistics
    - Results_main analysis EXP4_NC.spv: main results of the study
    -Results_main analyses_EXP4_revision01092015.spv: main results with additional contrasts
    -Output_Extra analyses groups and competition.spv: additional analyses (Chapter II dissertation)
    -Generalized extra analysis.xlsx: effect size calculations for the main results (incl. revision)
    -Effect sizes extra analyses.xlsx: effect size calculations for additional analyses

- [x] files(s) containing information about informed consent

    All study documents and the experiment itself, including informed consent, are stored on the individual PC of the main researcher and on an external hard drive.

- [x] a file specifying legal and ethical provisions

    The ethical committee approval is stored (S56294 N. Claes.pdf)

- [x] file(s) that describe the content of the stored files and how this content should be interpreted. Specify:

    Syntax files should provide an explanation of what each operation does in comments (indicated by "*"); in SPSS data-files (.sav), in the tab "variables", all original variable are provided with a label and an explanation of what the variable is

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [x] individual PC
- [ ] research group file server
- [x] other: external hard drive; Augias

* Who has direct access to these other files (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

    - co-author: Ann Meulders
    - Programmers and administrators of Augias: Jeroen Clarysse and Mathijs Franssen

4. Reproduction

* Have the results been reproduced independently?: [] YES / [x] NO

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Data Storage Fact Sheet Part III – Chapter III.1 (15/02/2016)

% Data Storage Fact Sheet version 15/02/2016
% Name/identifier study: **< PhD Nathalie Claes, Part III – Chapter III.1, contextual cues joystick movements>**
% Author: Nathalie Claes
% Date: 15/02/2016

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1b. Responsible Staff Member (ZAP)

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1c. Responsible Staff Member: Promotor KU Leuven (ZAP)

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- address: Tiensestraat 102, box 3726, 3000 Leuven
- e-mail: johan.vlaeyen@ppw.kuleuven.be

If a response is not received when using the above contact details, please send an email to secr-og@ppw.kuleuven.be or contact the Secretariat Health Psychology, Tiensestraat 102 box 3726, 3000 Leuven.
Another possibility is to send an e-mail to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

* Reference of the publication in which the datasets are reported:

> Under revision as: Claes, N., Vlaeyen, J. W. S, Crombez, G. Pain in context: cues predicting a reward decrease fear of movement related pain and avoidance behavior. *Behavior Research and Therapy*.
>
> PhD dissertation Nathalie Claes: Chapter III.1: The impact of cues predicting pain versus reward on pain-related fear and avoidance behavior

* Which datasets in that publication does this sheet apply to?:

> All datasets reported in this publication/chapter of the doctoral dissertation. All raw data was integrated in one "full" dataset, comprising of (1) output data from the experiment (self-reports, reaction time measurements); and (2) questionnaire data.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [x] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

- [x] researcher PC
- [ ] research group file server
- [x] other (specify):

    -Augias, The online research and data documentation platform of the research group Behavior, Health and Psychopathology of Leuven university, currently only accessible for registered users. The experiment is registered as "EXP3 Pavlovian to Instrumental Transfer in Pain". Augias contains an extensive description of the data and data-analysis.
    -An external hard drive on which all raw and full data are stored.

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

    -Programmers and administrators of Augias: Jeroen Clarysse (jeroen.clarysse@ppw.kuleuven.be) and Mathijs Franssen (mathijs.franssen@ppw.kuleuven.be)

3b. Other files

* Which other files have been stored?

- [x] file(s) describing the transition from raw data to reported results. Specify:

    SPSS syntax files to transition from raw data to a data-file that can be used for analyses; SPSS syntax files to merge all data from different input channels (experiment data; questionnaire data); SPSS syntax files with descriptions of statistical operations such as calculation means etc.; SPSS syntax files for the main analyses of the results (see Syntax.zip). All files are divided into subfolders (e.g. "data preparation", "data analysis") and contain key words in the titles. The syntax files contain commentaries throughout the text to indicate what a specific command does.

- [x] file(s) containing processed data. Specify:

    SPSS and Excel data file (see complete_Data_EXP3.zip)

- [x] file(s) containing analyses. Specify:

    SPSS output files containing the results of the study (See Results_EXP3.zip)

- [x] files(s) containing information about informed consent

    All study documents and the experiment itself, including informed consent, are stored on the individual PC of the main researcher and on an external hard drive.

- [x] a file specifying legal and ethical provisions

The ethical committee approval is stored (S56147 N. Claes.pdf)

- [x] file(s) that describe the content of the stored files and how this content should be interpreted. Specify:

Syntax files should provide an explanation of what each operation does in comments (indicated by "*"); in SPSS data-files (.sav), in the tab "variables", all original variable are provided with a label and an explanation of what the variable is

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [x] individual PC
- [ ] research group file server
- [x] other: external hard drive; Augias

* Who has direct access to these other files (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

-Programmers and administrators of Augias: Jeroen Clarysse and Mathijs Franssen

4. Reproduction

* Have the results been reproduced independently?: [] YES / [x] NO

* If yes, by whom (add if multiple):

- name: Lora Masui
- address: tiensestraat 102, box 3726, 3000 Leuven
- affiliation: thesis student, KU Leuven
- e-mail: lora.masui@student.kuleuven.be

Data Storage Fact Sheet Part III – Chapter III.2 (15/02/2016)

% Data Storage Fact Sheet version 15/02/2016
% Name/identifier study: **< PhD Nathalie Claes, Part III – Chapter III.2, contextual cues behavioral experiment>**
% Author: Nathalie Claes
% Date: 15/02/2016

1. Contact details

1a. Main researcher

- name: Nathalie Claes
- address: Tiensestraat 102, box 3726, 3000 Leuven OR Henri Dunantlaan 2, 9000 Gent
- e-mail: nathalie.claes@ppw.kuleuven.be or nathalie.claes@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Geert Crombez
- address: Henri Dunantlaan 2, 9000 Gent
- e-mail: geert.crombez@ugent.be

1c. Responsible Staff Member: Promotor KU Leuven (ZAP)

- name: Johan Vlaeyen
- address: Tiensestraat 102, box 3726, 3000 Leuven
- e-mail: johan.vlaeyen@ppw.kuleuven.be

If a response is not received when using the above contact details, please send an email to secr-og@ppw.kuleuven.be or contact the Secretariat Health Psychology, Tiensestraat 102 box 3726, 3000 Leuven.
Another possibility is to send an e-mail to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

* Reference of the publication in which the datasets are reported:

PhD dissertation Nathalie Claes: Chapter III.2 The impact of environmental cues on pain avoidance: a behavioral study

* Which datasets in that publication does this sheet apply to?:

All datasets reported in this publication/chapter of the doctoral dissertation. All raw data was integrated in one "full" dataset, comprising of (1) output data from the experiment (self-reports, reaction time measurements, movements); and (2) questionnaire data.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [x] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

- [x] researcher PC
- [ ] research group file server
- [x] other (specify):

-An external hard drive on which all raw and full data are stored.

-Augias, The online research and data documentation platform of the research group Behavior, Health and Psychopathology of Leuven university, currently only accessible for registered users. The experiment is registered as "EXP5_modulation of avoidance behavior". Augias contains an extensive description of the data and data-analysis and all files, except for the raw data due to the size of the data-files.

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

-Programmers and administrators of Augias: Jeroen Clarysse (jeroen.clarysse@ppw.kuleuven.be) and Mathijs Franssen (mathijs.franssen@ppw.kuleuven.be)

3b. Other files

* Which other files have been stored?

- [x] file(s) describing the transition from raw data to reported results. Specify:

SPSS syntax files to transition from raw data to a data-file that can be used for analyses; SPSS syntax files to merge all data from different input channels (experiment data; questionnaire data); SPSS syntax files with descriptions of statistical operations such as calculation means etc.; SPSS syntax files for the main analyses of the results. A description of the process can be found in Experiment 5_beschrijving dataverwerking.docx.
Syntaxes included are:
-syntax online questionnaires.sps: transition from online stored data to excel/SPSS file
-syntax descriptives online questionnaires.sps: calculating descriptive statistics from questionnaires
-syntax paper questionnaires.sps: data collected on paper
-data analyses_EXP5.sps

- [x] file(s) containing processed data. Specify:

SPSS data files:
-Questionnaires: QData_EXP5_03062015.sav (combined data of online and paper questionnaires)

-processed experimental data: EXP5_baselinecontingencies.sav, EXP5_test_ContingencyRegion.sav, and EXP5_fulldata_10082015_cleaned.sav

- [x] file(s) containing analyses. Specify:

SPSS output and excel files containing the results of the study, including additional analyses :
- 1_EXP5_descriptives24062015.spv
-2_EXP5_output data analysis.spv
-Generalized eta squared.xlsx: excel file containing effect size calculations
-output data analysis groups 29092015.spv: additional analysis
-data analysis groups effect sizes.xlsx: excel file containing effect size calculations for additional analysis

- [x] files(s) containing information about informed consent

All study documents and the experiment itself, including informed consent, are stored on the individual PC of the main researcher and on an external hard drive.

- [x] a file specifying legal and ethical provisions

The ethical committee approval is stored (Ethische commissie aanvraag Nathalie Claes.msg)

- [x] file(s) that describe the content of the stored files and how this content should be interpreted. Specify:

Syntax files should provide an explanation of what each operation does in comments (indicated by "*"); in SPSS data-files (.sav), in the tab "variables", all original variable are provided with a label and an explanation of what the variable is

- [ ] other files. Specify: ...

* On which platform are these other files stored?

- [x] individual PC
- [ ] research group file server
- [x] other: external hard drive; Augias

* Who has direct access to these other files (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

-Programmers and administrators of Augias: Jeroen Clarysse and Mathijs Franssen (also co-authoring the paper)

4. Reproduction

* Have the results been reproduced independently?: [] YES / [x] NO

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

Data Storage Fact Sheet Part VI – Chapter IV.1 (15/02/2016)

% Data Storage Fact Sheet version 15/02/2016
% Name/identifier study: **< PhD Nathalie Claes, Part IV Chapter IV.1 – clinical observational study interview>**
% Author: Nathalie Claes
% Date: 15/02/2016

1. Contact details

1a. Main researcher

- name: Nathalie Claes
- address: Tiensestraat 102, box 3726, 3000 Leuven OR Henri Dunantlaan 2, 9000 Gent
- e-mail: nathalie.claes@ppw.kuleuven.be or nathalie.claes@ugent.be

1b. Responsible Staff Member (ZAP)

- name: Geert Crombez
- address: Henri Dunantlaan 2, 9000 Gent
- e-mail: geert.crombez@ugent.be

1c. Responsible Staff Member: Promotor KU Leuven (ZAP)

- name: Johan Vlaeyen
- address: Tiensestraat 102, box 3726, 3000 Leuven
- e-mail: johan.vlaeyen@ppw.kuleuven.be

If a response is not received when using the above contact details, please send an email to secr-og@ppw.kuleuven.be or contact the Secretariat Health Psychology, Tiensestraat 102 box 3726, 3000 Leuven.
Another possibility is to send an e-mail to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

* Reference of the publication in which the datasets are reported:

> The protocol of the study in which this data was collected is published online and freely available on the Ghent University Academic bibliography as Claes, Nathalie, De Paepe, A., Decoene, N., Lauwerier, E., Legrain, V., Vlaeyen, J., & Crombez, G. (2015). Pain-attention-motivation project 1: protocol. Available at http://hdl.handle.net/1854/LU-7032736
>
> PhD dissertation of Nathalie Claes: Chapter IV.1 The assessment of goal conflict in Fibromyalgia: a daily reconstruction method

* Which datasets in that publication does this sheet apply to?:

> All datasets reported in this publication/chapter of the doctoral dissertation.

3. Information about the files that have been stored

3a. Raw data

* Have the raw data been stored by the main researcher? [x] YES / [ ] NO
If NO, please justify:

* On which platform are the raw data stored?

- [x] researcher PC
- [ ] research group file server
- [x] other (specify):

-An external hard drive on which all raw and full data are stored.
-Augias, The online research and data documentation platform of the research group Behavior, Health and Psychopathology of Leuven university, currently only accessible for registered users. The experiment is registered as "CLIN1 Assessment of goal conflict in a clinical population".
-Note that raw data reflects the data the interviewer typed in after the interview and the questionnaires participants completed via Limesurvey. The scanned paper versions of the interview data is only available on the researcher PC and the external Hard Drive (because of its large size)

* Who has direct access to the raw data (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

-Co-author: Emelien Lauwerier (UCLL)
-Co-author and advisor on statistics: Michel Meulders (KUL) has access to processed data
-Programmers and administrators of Augias: Jeroen Clarysse (jeroen.clarysse@ppw.kuleuven.be) and Mathijs Franssen (mathijs.franssen@ppw.kuleuven.be)

3b. Other files

* Which other files have been stored?

- [x] file(s) describing the transition from raw data to reported results. Specify:

A description of the process of datapreparation can be found in "PAMproject_datapreparation.docx".
SPSS syntax files to merge all data from different input channels (interview data; questionnaire data) e.g. 1_syntax_interview.sps, 2_merging data_27032015.sps, syntax_merging multilevel data.sps
SPSS syntax files with descriptions of statistical operations such as calculation means etc.;
SPSS syntax files for the main analyses of the results (see results.zip, containing separate folders for each type of analysis and including both the syntax and the output):
1)1_chronbachs alpha questionnaires: Chronbachs alpha.sps
2) 2_descriptives: 1_interview_syntax data analyses descriptives and frequencies.sps, 2_Interview_comparison sex age education between groups.sps
3) 3_conflicts: Conflicts frequencies and crosstabs.sps
4) 4_correlations: set 3_analyses patients - number of PR conflicts and core constructs

16122015.sps
5) 5_linear regressions: 20160114 Clin study linear regressions end-of-day variables.sps
6) 6_multilevel regressions: Syntax multilevel analysis 14012016.sps
7) 7_poisson regressions: 1_syntax_grand mean centering 08012016.sps; 2_syntax_poisson core constructs (centered) - conflicts 08012016.sps

- [x] file(s) containing processed data. Specify:

SPSS data files: see Full data files SPSS.zip: contains all processed data

- [x] file(s) containing analyses. Specify:

SPSS output files are saved in results.zip, in separate folders, also containing the corresponding syntax file (see above). Files include:

1)1_chronbachs alpha questionnaires: Output_chronbachs alpha 16092015.spv
2) 2_descriptives: 1_interview_descriptives and frequencies patient and control groups sociodemos.spv; 2_interview comparison sex age education between groups output.spv
3) 3_conflicts: Result_conflicts frequencies and crosstabs.spv
4) 4_correlations: set 3_analyses patients - number of PR conflicts and core constructs 16122015.spv
5) 5_linear regressions: 20160114 Clin study linear regressions end of day variables OUTPUT.spv
6) 6_multilevel regressions: 1_interview_factor analysis experience of conflict variables 11012016.spv, 2_interview_multilevel analysis experience of conflict_14012015.spv
7) 7_poisson regressions: 12_interview_grand mean centering outcomes 08012016.spv, Clin_output poisson 08012016.spv

- [x] files(s) containing information about informed consent

All study documents and the experiment itself, including informed consent, are stored on the individual PC of the main researcher and on an external hard drive.

- [x] a file specifying legal and ethical provisions

The ethical committee approval is stored (goedkeuring.pdf)

- [x] file(s) that describe the content of the stored files and how this content should be interpreted. Specify:

Syntax files should provide an explanation of what each operation does in comments (indicated by "*"). in SPSS data-files (.sav) and Excel data files (.xlsx) in the tab "variables", all original variable are provided with a label and an explanation of what the variable is

- [x] other files. Specify:

the protocol of the project was stored online and is freely available on the Ghent University Academic bibliography as Claes, Nathalie, De Paepe, A., Decoene, N., Lauwerier, E., Legrain, V., Vlaeyen, J., & Crombez, G. (2015). Pain-attention-motivation project 1: protocol. Website: http://hdl.handle.net/1854/LU-7032736

* On which platform are these other files stored?

- [x] individual PC
- [ ] research group file server
- [x] other: external hard drive; Augias

* Who has direct access to these other files (i.e., without intervention of another person)?

- [x] main researcher
- [x] responsible ZAP
- [ ] all members of the research group
- [ ] all members of UGent
- [x] other (specify):

    -Co-authors: Emelien Lauwerier, Michel Meulders
    -Programmers and administrators of Augias: Jeroen Clarysse and Mathijs Franssen (also co-authoring the paper)

4. Reproduction

* Have the results been reproduced independently?: [] YES / [x] NO
    Analyses have been conducted in collaboration between NC and MM

* If yes, by whom (add if multiple):

- name:
- address:
- affiliation:
- e-mail:

PUBLICATIONS

Journal articles in preparation

Claes, N., Crombez, G., Franssen, M., & Vlaeyen, J.W.S. (in preparation). The impact of environmental cues on pain avoidance: a behavioral study.

Claes, N., Vlaeyen, J. W. S., Lauwerier, E., Meulders, M., & Crombez, G. (in preparation). Goal conflict in chronic pain: a daily reconstruction method.

Articles submitted for publication in internationally reviewed academic journals

Claes, N., Vlaeyen, J.W.S., & Crombez, G. (under review). Pain in context: cues predicting a reward decrease fear of movement related pain and avoidance behavior. *Behavior Research and Therapy.*

Franssen, M.*, Claes.N.*, Vervliet, B., Beckers, T., Hermans D., & Baeyens, F. (under review). Reinstatement after human feature-positive discrimination learning. *Behavioral Processes.*

**joint first authorship*

Articles published in internationally reviewed academic journals

Claes, N., Crombez, G., Meulders, A., & Vlaeyen, J. W. S. (2016). Between the devil and the deep blue sea: avoidance-avoidance competition increases pain-related fear and slows down decision-making. *The Journal of Pain*. Advance online publication. doi:10.1016/j.jpain.2015.12.005

Claes, N., Crombez, G., & Vlaeyen, J. W. S. (2015). Pain-avoidance versus reward-seeking: an experimental investigation. *PAIN*, 156(8), 1449–1457. doi:10.1097/j.pain.0000000000000116

Claes, N., Karos, K., Meulders, A., Crombez, G., & Vlaeyen, J. W. S. (2014). Competing goals attenuate avoidance behavior in the context of pain. *The Journal of Pain*, 15(11), 1120–9. doi:10.1016/j.jpain.2014.08.003

Meulders, A., Karsdorp, P. A., Claes, N., & Vlaeyen, J. W. S. (2015). Comparing counterconditioning and extinction as methods to reduce fear of movement-related pain. The Journal of Pain, 16(12), 1353–1365. doi:10.1016/j.jpain.2015.09.007

Research protocols

Claes, N., De Paepe, A., Decoene, N., Lauwerier, E., Legrain, V., Vlaeyen, J., & Crombez, G. (2015). Pain-attention-motivation project 1 (PAM-I): protocol. Retrieved from http://hdl.handle.net/1854/LU-7032736

Awards

Claes, N., Crombez, G., Vlaeyen, J. (2015). Choosing is losing: Pain-avoidance versus valued nonpain goals. 4th Annual Conference of the Association for Researchers in Psychology and Health (ARPH). Ghent, Belgium, 5-6 February 2015. Best Poster Prize Award.

Claes, N., Crombez, G., Vlaeyen, J. (2014). Choosing is losing: Pain-avoidance versus valued nonpain goals. 44th Congress of the European Association for Behavioral & Cognitive Therapies. The Hague, The Netherlands, 10-13 September 2014. Second EABCT Poster Prize.

Meeting abstracts presented at international scientific conferences and symposia, published or not published in proceedings or journals

Claes, N., Crombez, G., Meulders, A., Vlaeyen, J. (2015). When goals compete: the impact of various types of goal conflict on pain-related fear and pain-related decision-making. Pain Research Meeting. Genk, Belgium, 24-25 September 2015.

Claes, N., Karos, K., Heyvaert, M., Vlaeyen, J. (2015). The health psychologist as a scientist-practitioner: A single-case experiment teaching approach. Annual Convention Association for Psychological Science (APS). New York, NY, USA, 21-24 May 2015.

Claes, N., Crombez, G., Vlaeyen, J. (2015). Pain in context: The impact of cues predicting reward versus pain on pain-related fear and avoidance behavior. Annual Convention Association for Psychological Science (APS). New York, NY, USA,21-24 May 2015.

Claes, N., Crombez, G., Vlaeyen, J. (2015). Choosing is losing: Pain-avoidance versus valued non-pain goals. 4th Annual Conference of the Association for Researchers in Psychology and Health (ARPH). Ghent, Belgium, 5-6 February 2015.

Zaman, J., Claes, N., Wiech, K., Van Oudenhove, L., Van Diest, I., Vlaeyen, J. (2015). Biasing somatosensory perception: differential effects of predictable and unpredictable pain. Pain Research Meeting. Genk, Belgium, 24-25 September 2015.

Claes, N., Crombez, G., Vlaeyen, J. (2014). Pain-avoidance versus reward-seeking: The impact of goal competition and goal preference. Pain Research Meeting. Maastricht, The Netherlands, 4-5 September 2014.

Publications

Claes, N., Karos, K., Meulders, A., Vlaeyen, J., Crombez, G. (2014). Non-pain goals attenuate avoidance behavior in the context of pain. Convention for the Association for Psychological Science (APS). San Francisco, CA, USA, 22-25 May 2014.

Claes, N., Karos, K., Meulders, A., Crombez, G., Vlaeyen, J. (2014). Non-pain goals attenuate avoidance behavior in the context of pain. Annual Conference of the Association for Researchers in Psychology and Health (ARPH). Groningen, The Netherlands, 6-7 February 2014.

Claes, N., Crombez, G., Vlaeyen, J. (2014). Choosing is losing: Pain-avoidance versus valued non-pain goals. 44th Congress of the European Association for Behavioral & Cognitive Therapies. The Hague, The Netherlands, 10-13 September 2014.

Claes, N., Karos, K., Meulders, A., Crombez, G., Vlaeyen, J. (2013). Valued non-pain goals attenuate avoidance behavior in the context of pain. Pain Research Meeting. Ghent (Belgium), 5-6 september 2013.

Claes, N., Karos, K., Meulders, A., Crombez, G., Vlaeyen, J. (2013). Valued non-pain goals attenuate avoidance behavior in the context of pain. Congress of the European Federation of IASP Chapters (EFIC). Florence, Italy, 9-12 October 2013.

Claes, N., Karos, K., Meulders, A., Crombez, G., Vlaeyen, J. (2013). Pain in Context: the influence of competing pain and non-pain goals on pain experience and fear of pain. European Meeting on Human Fear Conditioning (EMHFC). Affligem (Belgium), 22-24 May 2013.

Claes, N., Crombez, G., Vlaeyen, J. (2012). Are pain-related goal conflicts associated with increased fear? Pain Research Meeting. Marburg/Rauisscholzhausen, 10-12 October 2012.