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Topical review

Fear-avoidance model of chronic musculoskeletal pain: 12 years on

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1. Introduction

It is widely acknowledged that pain is a universal experience that affects human beings across the life span, serving an important protective function. Typical protective behaviors are the withdrawal from the noxious stimulus, nonverbal expressions that signal others for impending harm, and verbal utterances. Some of these occur involuntarily, as a reflex, whereas other behaviors are more deliberate. However, there is accumulating evidence that it is not pain itself, but the meaning of pain that predicts the extent to which individuals engage in these protective behaviors [1,3]. About a decade ago, we summarized the research evidence supporting the role of fear of pain in the development of chronic pain disability, presented a model incorporating basic mechanisms, but also noted a number of unresolved issues that called for further scientific attention [39] (Fig. 1). In the last decade, the number of studies on this subject has increased exponentially [21], and novel directions are being proposed [6]. Two main stances have emerged. First, although pain has intrinsic threatening features, the threat value of similar pain stimulus may vary across contexts and individuals. Second, protective responding may be adaptive in the short term, but may paradoxically worsen the problem in the long term. In the current updated review, we briefly summarize the progress made since, and highlight a selected number of remaining challenges and areas for future research.

2. The pain-related fear–disability association

In our 2000 review, the fear-avoidance (FA) model was introduced as a way to describe how pain disability, affective distress, and physical disuse develop as a result of persistent avoidance behaviors motivated by fear. The FA model has become increasingly popular, and a large body of evidence is in line with its assumptions. Research supporting the FA model stems from cross-sectional studies with chronic pain patients [21], prospective studies in acute pain [10,17,33] and studies using structural equation modeling examining the dynamic and sequential relationships among the variables of the FA model [11,40]. Collectively, these findings underscore the important role of pain-related fear in the development of disability. One of the unanswered questions, however, is how pain-related fear occurs in the first place.

3. The acquisition of pain-related fear

By virtue of its biological significance, pain is an important motivator in learning. Indeed, pain informs the individual that there is the imminent or actual threat of body damage. Therefore, pain is considered an unconditioned stimulus (US) that activates an immediate defensive system. Fostering successful adaptation, individuals subsequently anticipate the occurrence of a US by gathering propositional knowledge about the association between neutral cues or conditioned stimuli (CS) and the US. In Pavlovian conditioning, a conditioned response (CR) is elicited when the individual is exposed to a CS, also in the absence of the US. What kind of stimuli are involved in such learning, and what are the potential sources of information leading to such propositional knowledge (Fig. 2)?

Because of their relative ease to use, most fear learning researchers employ exteroceptive (mostly visual) stimuli. For example, when one color (CS+) signals the presentation of painful stimulus (US), and another color does not (CS−), participants usually respond with greater potentiated eye-blink startle, heightened skin conductance, and cardiac deceleration in the presence of the CS+, as compared to CS−, in the absence of the US [4]. In clinical situations, however, and by virtue of their functional proximity, interoceptive and proprioceptive stimuli, rather than exteroceptive ones, may be better predictors of pain as a US. Interoceptive stimuli are those that provide afferent information from receptors that monitor the internal state of the body [8]. Interoceptive fear conditioning therefore occurs when an association between and interoceptive CS and a US has been established [7]. Proprioception is restrictively defined as the perception of posture and movement, also referred to as postural somesthesis [20]. Proprioceptive fear conditioning is particularly relevant in patients with pain in the musculoskeletal system. A recent study used joystick movements, of which the direction predicted painful

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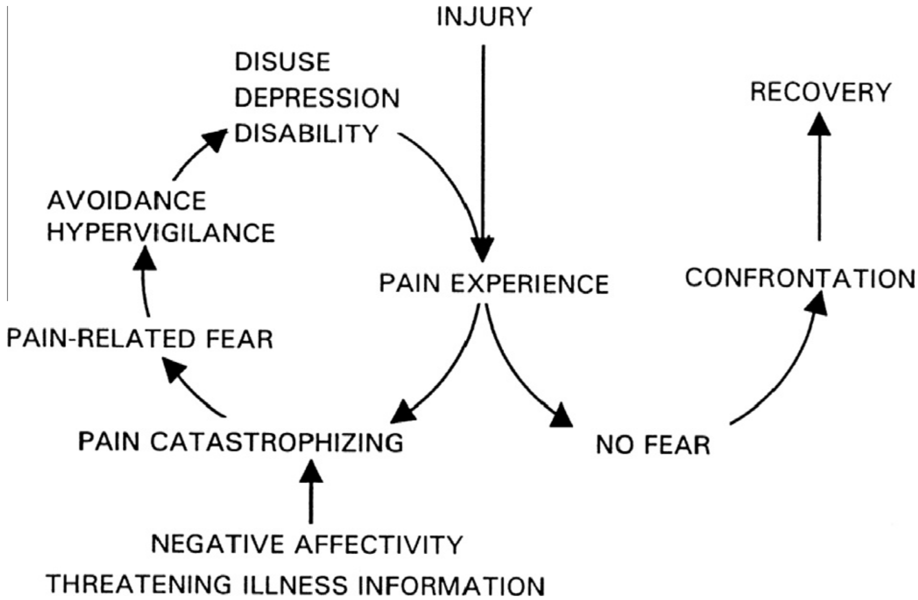

Fig. 1. Graphical display of the fear-avoidance model, reproduced from Vlaeyen and Linton [39].

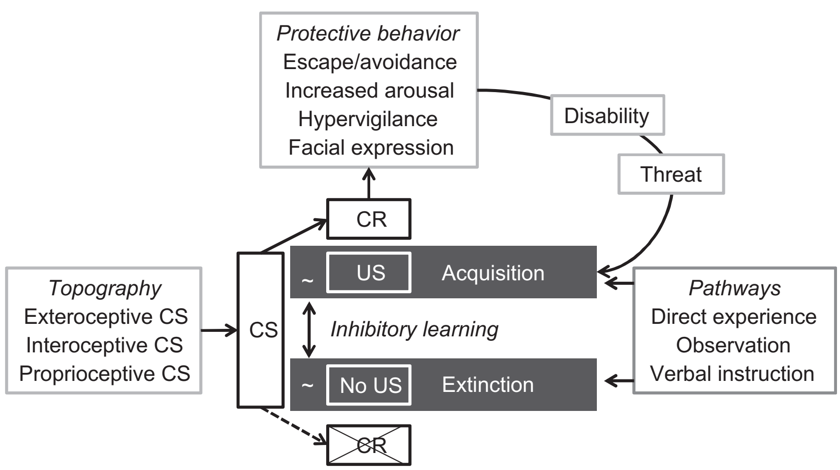

Fig. 2. Graphical display of the acquisition and extinction of pain-related fear, including stimulus topography, protective behaviors and possible pathways. US: Unconditioned stimulus, CS: Conditioned stimulus, CR: Conditioned response.

shock to the hand (e.g., moving upward as CS+ and moving downward as CS−) [26]. As compared with a condition in which both movements were explicitly unpaired with painful shock, the CS+ movement elicited increased fear of movement-related pain, larger eye-blink startle amplitudes, and slower movement latency responses than the CS−, validating the acquisition of fear of movement-related pain in healthy individuals.

Regardless of stimulus topography, at least 3 distinct pathways for acquiring knowledge between potential cues and pain have been proposed. First, people can learn from direct experiences, as was the case in the abovementioned studies [4,26]. However, there are also indirect pathways, such as transmission through verbal instructions or observation. Verbally transmitted information can hold semantically negative information that may yield relevant information about the relationship between 2 stimuli. For example, the threat value of pain can be manipulated by telling participants performing a cold pressor task, "when feeling a tingling sensation in your hand, this may be the first signs of frostbite" [36] or warning patients that "lifting weights may cause back injury" [16], without actually experiencing these associations. But there is also a nonverbal pathway, during which the mere observation of another person in pain can be sufficient to install fear of that particular stimulus [12]. In one study, participants observed human models who performed a cold pressor task, in which the color of the water (orange or pink) was associated with painful or neutral facial expressions [13]. When tested themselves, the observers' fear and pain scores show that they learned the CS–pain associations that they previously observed in the model, despite equal temperatures of both cold pressors. An intriguing yet untested idea is that interactions among these pathways may facilitate learning. For example, previous observational learning may enhance subsequent experiential learning of pain-related fear during the actual encounter of a similar CS−pain pairing.

4. The role of (un)predictability

Although fear conditioning research and its application to pain-related fear has been valuable for the understanding of chronic regional musculoskeletal pain, it may not be appropriate for more generalized pain disorders. Presumably because of lack of apparent safety cues, experiencing an unpredictable threat induces a more general form of distress, demonstrated by feelings of worry and chronic apprehension [27]. The degree of predictability may have an impact on the experienced pain intensity. Indeed, an interesting finding in the study using joystick movements was that in the unpredictable condition, both pain intensity and unpleasantness of the pain were rated significantly higher as compared with the paired condition, despite the equal number and physical intensities of the stimuli. The role of predictable versus unpredictable pain and the effects of different types of (un)predictability (pain duration, pain offset, pain location, pain quality, etc.) clearly warrants more systematic experimental scrutiny, and may open a novel window on the understanding of generalized pain syndromes.

5. Weighing pain and nonpain goals

Another concern with the current FA model relates to the idea that pain-related fear emerges in a context of multiple goals [6,37,38]. The goal to avoid pain is only one to be pursued in an environment with concomitant, often competing goals. Indeed, one of the most debilitating consequences of pain-related avoidance behavior is the withdrawal from previously valued activities. In this respect, chronic pain patients frequently weigh the value of their pain avoidance against the costs related to the loss of valued activities [31,32]. For example, in one study goal, self-efficacy, goal conflict, and pain severity independently predicted pain-induced fear, which in turn mediated the effects of goal conflict on physical disability and depression in chronic low back pain patients [18]. The idea that pain-related goal conflicts may increase the threat value of the pain is an intriguing one, largely left untested [19].

6. Novel assessment tools for pain-related fear

If pain-related fear mechanisms are a distinct trajectory by which acute pain becomes chronic, then they should be potent factors for identification. The Örebro Musculoskeletal Pain Screening Questionnaire was developed for this purpose, with which it is possible, with reasonable accuracy, to identify patients who risk developing persistent disability [14,25]. However, more research on the relative contribution of the FA variables on future outcome is needed to construct instruments with increased predictive accuracy. Also, the question remains regarding for whom, when, and where screening is best conducted, as well as how the information should be used in planning further assessment and treatment.

The challenge of assessment is to identify patients in whom pain-related fear and its ensuing avoidance are a significant problem. In our 2000 review, we called for broadening assessment techniques extending the cognitive aspects to the behavioral and physiological features. Today, advances have been made in self-report measures, but little progress in other aspects. Questionnaires have been further developed [9,30], alternative pictorial assessment methods are now available for identifying perceived "harmful" movements [22,34], and automated activity monitoring devices has been used [35]. One particular challenge is to objectively measure escape and avoidance behavior. Not just for the avoidance of fear-eliciting activities, but also for the more subtle safety-seeking behaviors, reliable and valid assessment methods are currently lacking [29].

7. The reduction of pain-related fear

Treatment procedures and the evaluation of their effects have developed dramatically. Exposure in vivo has a strong pedigree as one of the most powerful cognitive behavioral treatments for reducing disabling fear and anxiety, and has now been applied in patients with chronic pain [2,15]. Several single-subject experimental studies show impressive improvements in fear, catastrophizing, and function, which have initiated subsequent randomized controlled trials, (e.g., [23]). Although the results vary, effect sizes are at most moderate, suggesting room for improvement. Recent studies on the mechanisms behind exposure therapy reveal that CS–US associations are not "unlearned" during the extinction of fear, but that instead, inhibitory responses are learned during extinction. This means that the original (excitatory) CS–US association remains intact, but competes with a new (inhibitory) CS–"no US" association. Exposure can thus best be designed such that new nonthreat associations be formed, and subsequently generalized across time and contexts. Such an approach shifts the focus toward the inclusion of multiple CSs, eliminating safety behaviors during exposure and using mental rehearsal to bridge exposure contexts to other daily life contexts [5]. Given these new insights, remaining issues call for further scrutiny. What is the relative impact of actual exposure versus observational or verbally transmitted information about associations between the CSs and the absence of pain or its feared consequences [24]? Do the effects of exposure to proprioceptive conditioned stimuli generalize to interoceptive ones, and vice versa [7]? What is the moderating effect of patient levels of executive control? How can fear-reduction techniques be applied in secondary prevention [28]? What are minimal competencies for treatment providers executing exposure? Many of these ways to optimize the effects of exposure await experimental and clinical testing.

8. Conclusion

The last decade has seen a surge in the study of the FA model of pain in both basic and clinical investigations. The recent literature mainly supports the basic assumptions of the model, but it also provides greater depth, inspiring future research and novel clinical applications. In particular, the model draws on the associative learning, and experimental research provides a fertile ground for future work on the intricacies of its mechanisms. Research is needed, for example, to clarify how interoceptive stimuli might work as a CS, what the role of (un)predictability has on fear responding, and how competing goals may influence fear learning. Clinically, the FA model has made a contribution to advance our understanding of the development and reduction of persistent disability, but considerable challenges remain in order to harvest the full benefit of the knowledge gained. Future efforts should focus on developing more specific assessment procedures that could direct clinicians to the best treatment options and optimize tailoring. Although exposure techniques are clearly helpful, there is promise in developing them further in order to understand how the model operates in patients as well as for more effective applications. These new avenues are likely to strengthen the predictive validity and clinical utility of future FA models in the context of chronic pain and disability.

Conflict of interest statement

The authors have no conflict of interest to report.

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