

Cognitive biases in pain: An integrated functional-contextual framework

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1. Cognitive biases in the context of pain.

Contemporary models explaining the exacerbation and maintenance of pain, disability and distress, assign a pivotal role to cognitive biases. These models assume that cognitive biases are maladaptive, trait-like processes, and propose that individuals who selectively attend to pain-related information (attention bias), interpret ambiguous pain and/or health relevant information as threatening (interpretation bias), and/or recall pain-related information selectively or as more negative/threatening than initially experienced (memory bias), report higher levels of pain and disability and are at increased risk for developing chronic pain.^{10,11,15,16,51,56,77,87,93,94} This intuitively appealing idea has resulted in an exponential increase in research addressing the presence, antecedents, and consequences of cognitive biases in people experiencing acute and chronic pain.^{10,13,17,41,51,52,67,68,78} However, results are inconsistent and puzzling, with mixed support for theoretical-driven assumptions.^{12,41,67,87,88,93} The aim of this review is to (a) synthesize and discuss current knowledge on the role of cognitive biases in pain, (b) provide conceptual and methodological explanations for equivocal findings, and (c) develop an integrated functional-contextual framework for understanding the role of cognitive biases in pain. Based on this framework, we propose a new research agenda and discuss implications for clinical practice.

2. The presence and impact of cognitive biases in pain: The state of the science.

Research on cognitive biases in (chronic) pain has been guided by the research agenda on cognitive biases in psychopathology, where similar theoretical processes are proposed (e.g.,^{2,24,47}). As such, paradigms were adapted from psychopathology research (e.g., dot-probe^{1,21,37,73}, homograph or homophone task^{60,67}, word memory task^{36,66,72}) to investigate cognitive biases for pain-related information. These paradigms typically use symbolic descriptors of health/illness or pain experiences or situations (e.g., words and/or pictures, descriptions of ambiguous situations). Recently, a number of comprehensive reviews synthesized available evidence following this research tradition.^{13,52,67,68,78}

For attention bias, these reviews revealed small effects, indicating that people experiencing acute or chronic pain show a bias towards pain-related information, particularly sensory pain words.^{13,78} No bias was found in people without or merely anticipating pain.^{68,78} Most remarkably, no consistent relationship

was found between attention bias for pain and its theoretically-proposed antecedents (e.g., fear of pain) or consequences (e.g., pain severity).¹³ Equally inconsistent relationships have been found in prospective research^{42,43,44,74} and in youth with pain.^{6,41} For interpretation bias, a recent meta-analysis indicated that individuals with chronic pain tend to interpret ambiguous information as more pain-related than healthy individuals.⁶⁷ This meta-analysis also revealed a lack of research addressing the link between interpretation bias and its theoretically-proposed antecedents and consequences.⁴¹ The few studies investigating the link between pain severity or pain-related anxiety and biased interpretations for bodily threat in individuals living with chronic pain failed to find consistent associations.^{57,60, but see 39} Similarly, in healthy individuals, no systematic link was observed between pain-related anxiety and interpretation bias.^{38,81,82} Finally, a number of studies investigated memory bias for pain- and illness-related information in people experiencing pain. This research suggests that adults and youth with chronic pain recall more sensory pain words compared to neutral words (e.g.,^{18,55,64, but see 96}), whereas findings on recall of illness-related words are mixed.^{18,59,58} Interestingly, some studies showed that increased recall of illness-related or negative health words relates to increased negative mood, although further research is warranted.^{14,58} A consistent link between memory biases for pain-related information and its theoretically-proposed antecedents and consequences is however lacking.^{14,62,72}

In sum, there is limited evidence to support the role of cognitive biases for pain-related information in explaining the exacerbation and maintenance of pain and pain-related disability. Although there is evidence for the presence of cognitive biases in people experiencing pain, effect sizes are small to moderate and there is substantial heterogeneity between studies. This heterogeneity may be partly due to task parameters, such as stimuli (e.g., sensory vs. affective pain words^{13,78}) or instructions (self-referent vs other-referent instructions⁵⁸). However, much heterogeneity remains unexplained and available evidence does not show a robust link between cognitive biases for pain-related information and the theorized antecedents and consequences. Notably, research addressing the interaction between cognitive biases is lacking (see^{66,69,76} for exceptions). In addition, there is a need for prospective research investigating the link between cognitive biases and the development of chronic pain. Therefore, we argue that it is premature to draw definitive conclusions from the current evidence base. Furthermore,

we urge for a shift in the conceptualization and operationalization of cognitive biases to explain existing inconsistencies.

3. Towards an integrated functional-contextual framework

We propose that cognitive biases should be understood from an integrated functional-contextual framework. Key in this framework is that cognitive biases are conceptualized as functional phenomena driven by changing contexts and motivational factors. This conceptual framework has three key assumptions: Cognitive biases are (1) functional, (2) dynamic, and (3) interrelated and/or interacting.

(1) Cognitive biases are functional phenomena

The first assumption contradicts the popular view that cognitive biases are intrinsically maladaptive phenomena. Within proposed framework, cognitive biases are suggested to be functional processes and not *necessarily* maladaptive. We propose that the adaptive value of cognitive biases for pain depends upon *context*. This assumption is in line with an evolutionary account on cognitive biases (see also²⁵). In particular, we propose that cognitive biases may have an adaptive value in instances where identification of pain and adoption of protective responses to potentially threatening situations can prevent negative outcomes.^{17,84,93} However, when protective responses are unavailable or ineffective, the same cognitive biases may interfere with the pursuit of daily tasks or life goals. Whether cognitive biases to pain-related information are adaptive then depends on their ability to prompt a response that can avert negative pain-related outcomes balanced against the urgency and value of competing goals. When a negative pain-related outcome cannot be prevented or modulated, interpreting situations in a threatening manner and being highly attentive to pain-related information is likely to interfere with daily goals, without benefit. If this assumption is true, adaptive cognitive processing would require the ability to shift flexibly in the way that situation-specific features are interpreted in line with presented demands, which are dependent upon the actual threat level and possibility to influence this threat balanced with the pursuit of ongoing and/or future non-pain-related goals, and attention is deployed consistent with that interpretation. Memory processes may then allow for optimal deployment of cognitive processes in

future situations with similar situation-specific features. Based upon this assumption, we propose that it is inflexibility or rigidity in the way people attend, interpret, and remember pain information, irrespective of situation-specific features, such as active goals or changing contexts, that results in negative pain outcomes. Such inflexibility may be partly due to rule-governed behavior^{26,40} and/or reduced executive functioning abilities⁴⁵. Indeed, flexible adaptation in the way of attending to, interpreting, and remembering pain-related information to contextual demands requires executive functioning, including attentional and cognitive control.^{3,31,45,48}

(2) Cognitive biases are dynamic phenomena.

The second assumption proposes that cognitive biases are dynamic, fluctuating, and unfolding phenomena driven by motivational and contextual factors, rather than stable trait-like processes as often implicitly presumed.^{8,67,68,94} This is supported by increasing evidence that cognitive biases are influenced by active goal pursuit and contextual factors. For example, research has shown that attention bias for pain information increases when the goal to avoid pain is pursued⁵⁴, but diminishes in the presence of salient competing goals^{70,71} (e.g., rewarded task performance). Furthermore, attentional biases have been found to vary as a result of the threat of an anticipated pain-related task.⁷³ For interpretation bias, Moseley and Arntz (2007) showed that contextual cues (i.e., blue vs. red colored cues) influenced how ambiguous nociceptive stimuli are experienced,⁴⁹ Finally, numerous studies showed that the affective context (e.g., anxiety) of caregivers and the individual experiencing pain exerts influence on the magnitude of memory bias.^{22,23,32,50,51} Each of these examples shows that cognitive biases are dynamic and supports the assumption that they are influenced by context and motivation. Differences in motivation may be due to a number of factors, including the relative importance of pain-relevant or competing goals, goal pursuit opportunities and experienced emotions.^{7,84,88} Motivation may not only be influenced by proximal state variables, but may also be influenced by more distal trait-like individual difference variables, such as health anxiety, anxiety sensitivity, or pain catastrophizing. Systematic research is needed to address the impact of pain-relevant versus pain-irrelevant goal pursuit and context

variables (e.g., presence of safety cues, presence of significant others, caregiver affect etc.) on the direction and magnitude of cognitive biases. Furthermore, we contend that one cannot simply translate findings on cognitive biases from one context (e.g., a lab context) to another (e.g., a daily life context), without considering motivational and contextual factors. As such, the proposed framework underscores the need for future research to consider goal pursuit and context variables.

(3) Cognitive biases are interrelated

In line with the recent call to investigate the relationship between different cognitive biases in the field of pain^{69,77,92}, we argue for an integrative model in which cognitive biases are interrelated and interacting. Similar to the combined cognitive bias hypothesis, we propose that the relationships between cognitive biases are bidirectional.^{29, but see 27,77} In the simplest way, early attention is captured by ambiguous bodily sensations, which are then interpreted as either threatening or non-threatening. This interpretation affects later attentional processes and may consequently impact how the situation is remembered.^{19,77} Finally, the pain memory is activated in the future when similar bodily sensations are experienced, which will invariably influence attention and interpretation.⁵³ Within this view, we argue that the interrelationship between cognitive biases is likely due to shared underlying mechanisms -i.e., motivation and contextual variables- that fuel their potential co-occurrence. Yet, it may well be that cognitive biases are not merely interrelated, but have cumulative effects and hence, particular combinations of cognitive biases have an amplified effect upon pain outcomes compared to their impact alone.²⁹ Since research investigating combined cognitive biases in the field of pain is still in its infancy, these hypotheses remain speculative. Hypothesis-driven and systematic research simultaneously addressing cognitive biases is needed to elucidate how they interrelate and interact with each other to affect pain intensity, pain-related disability and the development and maintenance of chronic pain.

4. The future research agenda for cognitive bias research

Adopting an integrated functional-contextual framework to explain the presence, direction, and dynamics of cognitive biases brings exciting new research avenues, as well as important methodological

challenges. Many of these challenges relate to the typical assessment of cognitive biases in the context of pain. The majority of studies involve a *single assessment* of a *single cognitive bias* for *symbolic representations* of pain or health using *a computer task in the laboratory*. Yet, if biases are interrelated, dynamic, and context-specific, as we assert, these typical laboratory assessments do not comprehensively or validly capture the nature of cognitive biases for pain as theoretically-proposed and as they would occur in real-world contexts. To propel cognitive bias research in the field of pain, we make the following recommendations. First, researchers need to ensure that the stimulus material used in cognitive bias research is relevant to the sample and the context. This may be even more challenging due to the large heterogeneity in pain samples and common comorbidity with psychopathological disorders, such as anxiety and depression.^{46,95} The investigation of cognitive biases using actual pain⁵³, pain-relevant body locations⁸⁵, signals of impending pain^{9,90} or ambiguous somatosensory stimuli⁴⁹ may increase the relevance of pain information. Furthermore, avoiding the use of symbolic pain information (particularly words) reduces the possibility that familiarity with the information (i.e., pain patients more often use pain-related words than healthy persons) can explain cognitive bias findings due to better recall of and altered attention to familiar information.^{20,63} In similar vein, the link between various cognitive biases should be investigated in relation to similar relevant stimuli, as the presence and magnitude of biases may be determined by the particular type and relevance of pain-related stimuli.⁹² Second, cognitive biases are typically investigated without taking context into account and in isolation from active goals, which are common in individuals' daily lives (see^{70,71} for an exception). Researchers should aim to test theory-driven hypotheses in dynamic functional contexts by implementing real life actions and/or goals during pain.^{9,84} This may be achieved by bringing realistic (daily life) goals and contexts into a controlled laboratory setting (e.g., by using virtual or augmented reality).^{80,86} Manipulating the features of active goals and the context (e.g., safe vs. dangerous; controllable vs. uncontrollable; stressful vs. relaxed) during the assessment of cognitive biases for pain will provide a better understanding of the dynamic nature of cognitive biases in daily life. Alternatively, researchers may assess cognitive biases in the daily lives of people experiencing acute/chronic pain⁶⁵ by developing novel paradigms to assess information-processing in daily life. Ecological momentary assessment methods may then be used to assess pain outcomes, context and motivational variables.³⁵ Third, we propose that inflexibility in

attending, interpreting, and recalling pain-related information may be central for negative pain outcomes, rather than the temporary presence or direction of cognitive biases. Current study designs often do not enable investigating flexibility in the way that people attend, interpret, and recall pain information (see^{89,97} for an exception). Using repeated measurements of cognitive biases for pain-related information in varying contexts would (a) increase the representativeness of the existence and magnitude of cognitive biases for pain in daily contexts and (b) allow to determine whether a person is flexible in the way he or she attends, interprets, and recalls pain-related information. Fourth, researchers should move beyond examining the impact of isolated cognitive biases on pain outcomes. Indeed, although examining single biases is valuable for understanding the exact phenomenon it provides only one piece of the larger puzzle to explain higher levels of pain and disability and increased risk for developing chronic pain. Without adopting an integrative view, including the relationship between cognitive biases, active goals and context, equivocal findings will likely remain unexplained.

5. Clinical Implications.

Our integrated functional-contextual framework also has consequences for the treatment of acute and chronic pain. First, we suggest that targeting cognitive biases without considering context or goal pursuit is likely to prove ineffective. For example, attention bias modification interventions focus upon training attention away from pain-related information independent of context or goal pursuit. Although such training may affect cognitive biases within the trained context^{4,5,33,74}, it often proves futile in different contexts.^{27,91, but see⁷⁴} The current model suggests that treatment should (a) target contextual and motivational, including affective, factors that drive cognitive biases; and/or (b) increase flexibility in the way that people attend, interpret, and recall pain-related information. Clinical psychologists have a plethora of techniques to target and change motivation (e.g., motivational interviewing⁸³). Clinicians may also be more effective in impacting cognitive biases for pain by targeting the meaning or the threat value of pain or increasing peoples' awareness of their personal goals by using cognitive behavioral therapy or acceptance and commitment therapy.^{34,61,77,87} Finally, one may also aim to directly train people to flexibly attend, interpret, and remember pain-related information in a changing environment.³⁰

In addition, the current framework provides a clear imperative to investigate the interplay between cognitive biases, which can help to identify under which circumstances it is helpful to target a single bias or multiple interacting cognitive bias(es) or their underlying mechanisms of action.⁹²

6. Conflict of interest statement

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