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Abstract: Recent developments in clinical, cognitive and behavioural sciences as well as in social neuroscience can provide new perspectives on our understanding of different forms of pain expression and the social reactions of observers to various types of pain expression. Studies indicate that pain expression is governed by both automatic (unintentional, reflexive) and controlled (intentional, purposive) neuroregulatory systems. Reciprocal mechanisms in observers responsible for automatic (unintentional, reflexive) and controlled (intentional, reflective) reactions also appear important. Observers appear more likely to display immediate "visceral", emotional reactions to unintentional, reflexive expression, whereas controlled expression characterized by purposive behaviour appears more likely to elicit reflection on the nature and origins of the person's pain. This review summarizes research within the context of a theoretical model for understanding how pain is perceived in others. Perspective: People attempting to understand another person's pain may have access to the person's spontaneous behavioural reaction as well as verbal report and other purposive communications. The former instigates reflexive and emotional reactions whereas the latter tends to be perceived as confounding expression of experience with response to situational demands.

Focus Article

Perceiving Pain in Others: Automatic and Controlled Mechanisms

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Abstract

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Perspective: People attempting to understand another person's pain may have access to the person's spontaneous behavioural reaction as well as verbal report and other purposive communications. The former instigates reflexive and emotional reactions whereas the latter tends to be perceived as confounding expression of experience with response to situational demands.

Perceiving Pain in Others: Automatic and Controlled Mechanisms

Recognizing and interpreting the significance of pain expression in others can be of great importance to the suffering person and the person witnessing the other's distress. Various actions, including language, paralinguistic vocalizations, facial expression, body posture, and escape or avoidance behaviour, may signal pain to others. These events can command the attention of observers from perspectives of both self-interest and social beneficence (and sometimes malevolence). They permit recognition of potential danger and provide opportunity for harm avoidance at the same time as they allow appreciation of what is happening to the person in pain, perhaps leading to provision of care[45, 41, 92]. The adaptive value of responding to pain in others is embedded in the evolutionary history of humans and ancestral species[7, 27, 30,87,90]. Despite its importance, the study of the social transaction initiated by pain expression is not well developed[80,82,91] although it is fundamental for understanding pain assessment in research and clinical practice[83].

Recent developments in clinical, cognitive and behavioural sciences as well as in social neuroscience can provide new perspectives on our understanding of different forms of pain expression and the social reactions of observers. Studies indicate that pain expression is governed by both automatic (unintentional, reflexive) and controlled (intentional, purposive) neuroregulatory systems[43]. Reciprocal mechanisms in observers responsible for automatic (unintentional, reflexive) and controlled (intentional, reflective) reactions also appear important. This review summarizes research within a theoretical model of how pain is perceived in others.

The Background

Tapping into the pain experience of another through use of painful expression is a challenging task. Expression can only partially represent the complexity of the subjective experience; hence, they are not equivalent[26, 43, 55, 56, 86]. At the neurobiological level of analysis, different systems are associated with pain experience and expression. Studies of sensory and affective features of pain experience have

focused upon afferent nociceptive and neuropathic mechanisms and central processing[15], whereas investigations of pain expression necessitate examination of systems responsible for language and efferent neuromotor regulatory mechanisms[80,88].

Operationalizing the distinction between pain experience and expression poses problems. From the research perspective, experience cannot be studied through other than some form of expression. Inevitably, understanding the pain experience of another requires inference. One can identify various cues to be important for observer judgments in the behaviour of the person in pain (self-report, other features of vocalizations, facial activity, body activity, limb withdrawal, writhing, and other nonverbal behaviors). Other evidence such as the presence of precipitants of injury[50,61], actual bodily injury, and physiological response to tissue stress or pathology[5] can also influence judgements. However, the presence and experience of pain are often poorly related to the nature and magnitude of tissue stress or damage[11]. The inferences and judgments of observers necessitate attention to the behavioural reactions of the person in pain.

The primary resources available for examining the subjective experience of pain are self-report and nonverbal expression, categories of pain response that are readily differentiated and usually identified as conceptually different. In tightly controlled studies, they can be highly correlated[55]; more typically they are only modestly correlated, with contextual factors determining the magnitude of the relationship[56, 70].

In competent, well-motivated people, *self-report* can provide a valid estimate of pain. But the need for competence in cognitive functioning and the potential for biased responses reflecting sufferer expectations and needs cannot be ignored[51, 78]. The individual's perception of optimal performance and outcome in a given setting appears crucial and determines self-presentation. Those *assessing* the person for pain also may bias self-report by providing cues as to what level of report is expected or appropriate. Thus, self-report must be recognized as representing some combination of expression of personal experience and a response to an appraisal of the immediate situation.

Nonverbal expression typically is endorsed as important when infants, young children, seniors with dementia, or others with communication limitations are unable to provide self-report[17, 46]. However, nonverbal assessment is also important in everyday and clinical social discourse. Nonverbal expression typically adds context and meaning to language and can be perceived as more credible than self-report because it is not as subject to conscious control as the use of language[67]. But similar to self-report, nonverbal expression is not exclusively reflexive. It also confounds subjective experience and situational demands. Nonverbal expression is sensitive to audiences[54, 69, 81,85]. People also can be reasonably successful in suppressing or exaggerating nonverbal pain expression[26, 48, 44, 58], in accordance with perception of situational demands, thereby again confounding spontaneous with socially predicated expression. It is not surprising that observers, clinicians or otherwise, experience difficulties in determining whether either self-report or nonverbal behaviour represent manifestations of pain experience or reactions to self-serving or situational demand biases.

We propose an alternative classification that distinguishes between automatic, reflexive features of the response to pain, perhaps best illustrated by the protective nociceptive flexion reflex[36, 9], and expressions of pain that reflect higher levels of central processing or purposive, deliberative control. Automatic reactions, whether in response to pain or other life events, tend to be sufficiently transparent so as to signify their direct meaning, and include "screaming in pain, laughing with joy, and growling with anger"[60], (p. 29). Controlled, intentional expression is typified by the use of language for self-report purposes but also would include integrated sequences of instrumental motor activity[43, 56]. The distinction is important because observers are disposed to attributing causes to other persons' actions[47, 59]. Reflexive activity is considered to have quite different functional implications than activities that are suggestive of deliberate intention and executive control. Complexity is added by the reality that although pain behaviour may be unintentional (e.g., facial expression, or even nociceptive pain reflexes),

it can be controllable to a certain extent (e.g., inhibiting facial expression, exaggerating withdrawal reactions, etc.)[52, 68, 71].

The distinction between systems that are automatic, on the one hand, or subject to processing and control, on the other, also characterizes observer reactions. Witnessing others reacting to acute painful events is capable of instigating immediate "visceral" or gut level emotional experiences[16]. The rapidly unfolding social neuroscience literature on cerebral correlates of witnessing others in painful distress documents the brain states to be observed[50,63, 73]. These automatic, uncontrollable reactions are accompanied by immediate attention and parallel controlled reflective appraisal of the nature of the other person's situation, as well as attention to likely sources of the activity observed, as the observer seeks to understand what is happening to the other person.

The theoretical distinction between two major observable behavioural sources of information concerning another person's pain experience and two major patterns of reacting to others in pain arises from theoretical and empirically derived models of information processing implicating at the extremes automatic and controlled mechanisms, with these interrelated and operative in varying degrees[62,34]. The proposition that human performance results from an interplay between automatic and controlled processing of information[72] is predicated upon the understanding that in complex environments attention must be guided to process critical stimuli, yet other routine, well rehearsed and overlearned activities are executed repetitively without demands on attention. It has been applied to understanding social interaction phenomena in other contexts[77, 3] including study of such phenomena as automatic stereotype activation[2, 12]

The following elaborates on this distinction as it contributes to understanding how those experiencing pain react and how observers respond to different forms of pain display.

Automatic and Controlled Features of the Behaviour of the Person in Pain

Systematic differences in the categories of painful expression set the occasion for variation in how observers perceive and respond to the person in pain.

Unintentional expressions of painful experience. Automatic pain manifestations are involuntary, spontaneous, triggered, stereotyped, predisposed sets of behavioural reactions elicited by noxious stimuli. They accompany but do not wholly or exclusively represent the sensory, affective and cognitive features of pain. From a physiological perspective, they are the somatomotor features of the coordinated central, hormonal, and autonomic response to tissue insult that have the relatively distinctive character of preparing the person to defend against tissue damage.

In considering types of automatic behaviour it is useful to distinguish between observable actions that are directly protective, because they permit escape or avoidance of sources of pain, and those that are indirectly protective because they communicate distress to others, thereby eliciting their protective interventions[80]. The former are represented by withdrawal reflexes and assuming guarded postures[53]. They act largely outside conscious awareness and deliberation. Communicative actions can also be reflexive or automatic. Infant behavioural reactions to painful events are reasonably seen as evolved protective behaviour, with control only emerging later on in infancy[23, 42, 60]. During the earliest moments and months of life, some of the protective behaviour is primarily in the form of social communication, for example, crying or facial expression, thereby informing parents and other adults potentially able to intervene with sources of distress and/or danger[42].

Many communicative and other protective actions are reasonably construed as biologically prepared and unlearned. In older children and adults, continuity and stereotypy in various manifestations of pain can be observed[23]. Features of facial expression, paralinguistic qualities of speech, guarded behaviour and protective posture would appear to satisfy criteria for unintentional signs of pain, i.e., they are reflexive, display striking structural and functional consistency across the life span, the person largely is not aware of them, but they can be controlled to a certain extent. Criteria for automatic actions, as defined by Moors & De Houwer[62] include processing at a relatively non-conscious

level, efficiency in terms of not requiring effortful processing, absence of a formulated goal, and being purely stimulus driven Concerning observable actions relevant to social communication, facial expression is typically the most salient and instructive for the observer[24, 70, 90]. A relatively stereotyped facial display of pain has been identified that is distinguishable from non-noxious emotional states, both behaviourally, in the judgments of others[74] and in observer brain states documented through neuro-imaging[73], but other socially relevant actions may be identifiable, for example, cry and paralinguistic qualities of speech.

Automatic responses are expected to be relatively stimulus driven and independent of attention and contextual influence[62]. However, it is clear that emotional and cognitive factors may modify reflexive responses, for example, stress induced analgesia is capable of diminishing reflexive withdrawal responses in rats and humans[35] and negative emotions can potentiate startle in humans[6]. While facial expression is a candidate for relatively immediate responding without conscious attending to the display, it is context-sensitive and linked to environmental demands. For example, presence of an audience of strangers tends to inhibit facial expression of pain[54], although children who engage in high levels of catastrophizing appear to indiscriminately display pain and are less likely to suppress pain expression[86]. Furthermore, automatic responses are to some extent subject to voluntary control, for example, suppression[71] or enhancement[48]. As children mature, originally automatic manifestations of pain come at least partially under voluntary control. For example, the essentially reflexive crying of the neonate becomes more of a speech act[25] and children learn to suppress pain expression in the presence of peers when negative reactions are anticipated[58]. Control can be achieved over facial displays of pain[22], including both exaggeration and suppression of the display; however, the exaggerated display differs from the genuine display in subtle ways[49], and neither faking nor suppression of facial displays are wholly successful[44, 67].

Intentional expressions of painful experience. These can be construed as typically deliberate, conscious, and coordinated by executive functions[1]. The latter are implicated when complex cognitive

sub-processes such as planning, anticipation, and decision-making become engaged. The use of language appears to best illustrate controlled expression of pain. It is noteworthy that complex, coordinated or innovative responses to situational demands can come to be relatively automatic, in this instance enacted without deliberation, when thoroughly well rehearsed in particular situations[3, 62].

Understanding controlled expression would appear to be more important to understanding human pain expression, although continuity in controlled expression across primate species is evident[27]. Interaction between automatic reactions and controlled expressions would be expected, with the latter coming to modulate the former in the course of human ontogeny, but there are limits to the extent that automatic expressions can be over-ridden by conscious control.

Automatic and Controlled Features of Perceiving Pain in Others

Cues related to pain in another person have the potential to influence observer perception of pain, some as a result of automatic activation, with others acquiring meaning only through conscious deliberation and executive processing. The act of perceiving others in pain has been characterized in a theoretical model of pain empathy as the product of both bottom-up and top-down variables[38, 39]. "Bottom-up" information is derived through perception of the actions of the person manifesting pain. The concept refers primarily to automatic reactions to the painful reactions of others and would implicate the detection of pain. This is appraised and achieves significance for the observer through utilization of "top-down" information reflecting application of the beliefs, expectancies, attitudes and biases of the observer, a process characterized by greater levels of controlled processing..

Automatic Reactions. These are characterized as reflexive, intuitive, automatic "gut feelings" evoked by the pain reactions of others. These "visceral" reactions are reasonably construed as more ancient in their evolutionary origins, conserved across phyla by virtue of their functional advantages in warning, motivating and protecting progenitors, thereby increasing reproductive fitness. There would appear to be automatic processing of cues through biologically prepared innate, unconditioned feature detectors that give rise to reflex-like responses. Current brain imaging studies of biological reactivity

demonstrate a powerful and immediate biological impact of the experience of witnessing others in pain on observers[8, 28, 50, 63,73,76].

Reactions are influenced by contextual factors (e.g., setting and social cues, and characteristics of the person in pain[19,29, 40, 57]. The relationship between the observer and the person in pain can dictate the reaction and perhaps commitment to the person in pain. This is evident in both behavioural and brain imaging studies. For example, judgements of pain in infants differ systematically across parents, nurses and pediatricians[65] and the perceived fairness of others expressing pain were found to modulate empathic neural responses[75].

Automatic reaction patterns would not be restricted to reflexive or autonomic activation, but could include automatic instigation of thoughts, beliefs and biases. Inherent sensitivity would appear to involve matching of stimulus input to prepared schema, thereby instigating unconditioned and coordinated reaction patterns. In turn these reactions would be amenable to conditioning and yield templates that guide automatic evaluation of perceived threat and reactions thereafter[4, 10, 64, 84].

Controlled processing. When an observer attends to another person's plight, automatic reactions would be accompanied by efforts to understand and plan actions suitable to the situation[77]. There is a need to know not only what is happening to the individual but also why this is happening, what sequence of events led to the person's painful distress, and what the person could do, or what the observer could do to resolve the situation. Problem-solving, memory, judgment, attitudes and biases are likely to be implicated. This higher level of neuroregulatory information processing would implicate executive functions[52,79]. Automatic processing is reasonably effortless or passive, with controlled processing more likely to predominate when conflicting or disconfirming evidence is present and active deliberation is necessary to resolve contradicting information and demands[77]. Both unconscious processing and consciously guided conceptual-level processes would come into play, allowing observer knowledge to refine judgements about the nature of the other's distress. Thus, elements of automatic processing are implicated in controlled reactions. There would be consideration of risks and appraisal of

strategies for harm avoidance for oneself and the person in pain[92, 41]. Beliefs (true and false), expectations, or prior knowledge would have an impact, as would the capacity for self-regulation of emotions, and empathy. Reasoned appraisal should lead to a broad understanding of the other's experience, its origins and likely outcomes. While one can distinguish between bottom up and top down processes, they operate in parallel, with conscious processing persisting longer than the immediate spontaneous reaction[38].

Interactions between controlled and automatic processing in sufferers and observers

Observer reactions appear to vary systematically with the different categories of pain expression in the person being observed (see Figure 1 for a schematic representation of the interaction). Expression of pain indicative of automatic reactions to situations (reflexes, emotional reactions) instigates different reactions in observers than controlled reactions indicative of planned, goal-directed behavior. Thus, different manifestations of pain would not be equivalent to others in their capacity to instigate particular reaction patterns.

Observer reactions to automatic expression. These stimulus driven reactions would be intuitive and immediate. The observer need only be passive, but the impact appears potent. Facial displays depicting vivid emotional expression have been found to be particularly effective in commanding attention and to be prepotent in their impact[37]. Little cognitive participation in the emotional reaction would be expected, although efforts to understand what is happening would also be immediately instigated (controlled reactions). In the primordial world, through to the present, observing these reactions in others would instigate a sense of personal danger with fear for the other person a subordinate response[45,73,92].

It is noteworthy that the cues most likely to instigate emotional processing fall in the domains of raw visual or auditory experience. These sensory modalities are also basic to reading and speech but these human capabilities rely extensively upon more complex, learned cognitive skills. Linguistic and literacy skills come to be acquired slowly during development of the child, signalling the complexity of

the cognitive processes engaged when language or written communications are used to convey information about painful states. The semantic features of self reports rely upon symbolic/linguistic mediation, or top down processing. However, paralinguistic qualities of speech convey the emotional or mood status of the speaker and some forms of language (e.g., swear words, particularly evocative language used by authors or patients, or poetry) are capable of instigating immediate, vigorous visceral reactions[66]. Language also has a capacity to automatically instigate certain automatic appraisals of events from memory when objects of attitudes are encountered, for example, prejudices[32, 33].

Observer reactions to intentional expression. While also immediate, these observer reactions would be of longer duration, as decoding and appraisal of information would require complex and effortful[62] cognitive processing. This would require attentional and problem solving resources, as effort was expended to sort out competing interpretations. The subtle nuances of language are important in differential diagnosis as alternative explanations of signs and symptoms are explored. In everyday social experience, when pain complaints are made, there must be similar searches among competing explanations of the origins of the individual's complaints. Listeners are likely to appreciate that the account is determined by both internal states being described and the speaker's appraisal of the situation.

The suffering person's capacity to control expression would make the expression more difficult to understand, more ambiguous as to its origins, and less readily interpreted as the immediate product of specific stimuli. It seems less likely that controlled reactions alone would be capable of triggering the same full empathic emotional reactions provoked by automatic bottom up stimuli, although, as discussed above, skilled narrators or writers seem capable of generating verbal scenarios capable of provoking resonant reactions in others. Patients often work hard to present convincing cases of the gravity of their condition[89]. Given awareness of the potential for voluntary control, risks of fabrication may be appraised.

People presenting with pain invariably are subject to careful appraisal by others[18, 82]. While trust seems the accepted norm and clinicians are routinely enjoined to believe patient self-report of pain,

optimal care giving and prudent stewardship of resources require judgements about the legitimacy of the representations of the person in distress. Medically unexplained pain appears particularly susceptible to doubts about the credibility of complaints. Patients for whom there is no scientific explanation of their pain are described as at risk of being marginalized from meaningful professional care and treatment[14]. In the absence of medical evidence for tissue damage or stress, examiners must rely upon symptom complaints; hence, credibility is likely to be questioned. Universal propensities to detect cheaters have been postulated by evolutionary biologists to account for careful scrutiny of others in social transactions[13,20,48,49 ,90]. Prkachin, Solomon and Ross[70] observed that suspicions surrounding the motivations of the patient impacted pain judgments during clinical decision making. Enjoining health care practitioners to utilize and believe self-report to some extent appears to be founded upon implicit recognition of the limited effectiveness of self-report in generating resonant feelings in observers.

Conclusions

Understanding the process whereby observers infer the presence and nature of pain in others requires an appreciation of the interaction between the expressive behaviour of people manifesting pain and the multiple affective and cognitive systems regulating the reactions of observers. The distinction between automatic and controlled information processing systems appears valuable in interpreting both the reactions of people in pain and of observers whose attention is directed to understanding the experience of the person in pain. The appraisal of the observer appears driven by both self interest and altruistic concern. The experience of pain in others can alert observers to risk of personal danger, as well as the potential that the other person requires care. Spontaneous (automatic) expressions of pain are more likely to instigate strong empathic reactions in observers, whereas controlled expressions that lack spontaneity are more likely to lead to questions about credibility. Understanding the complexities of the interaction between persons in pain and those reacting to them is likely to enhance delivery of care.

Figure 1:

		EXPRESSION OF PERSON IN PAIN	
OBSERVER REACTION		**Automatic** (reflexive escape, facial grimaces, cry)	**Controlled** (deliberate self-report, purposive actions)
	Automatic (involuntary, gut level)	LIKELY: involuntary emotional responses	LESS LIKELY (but possible)
	Controlled (contemplation, active decision-making)	PARALLEL: including delayed reflection	LIKELY (reflection, question credibility)

Figure 1. A representation of the probable reactions of observers to automatic and expressive displays of people in pain. Automatic expression is likely to instigate automatic, emotional reactions, as well as parallel cognitive appraisal. Controlled expression is less likely to evoke powerful automatic/emotional reactions in observers, but will instigate reflection and interest in various sources of the expression.

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Figure Legend

Figure 1. A representation of the probable reactions of observers to automatic and expressive displays of people in pain. Automatic expression is likely to instigate automatic, emotional reactions, as well as parallel cognitive appraisal. Controlled expression is less likely to evoke powerful automatic/emotional reactions in observers, but will instigate reflection and interest in various sources of the expression.

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Focus Article

Perceiving Pain in Others: Automatic and Controlled Mechanisms

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Running title: Perceiving others' pain

Key words: assessment, expression, empathy, reflexes, self-report, credibility

Abstract

Recent developments in clinical, cognitive and behavioural sciences as well as in social neuroscience can provide new perspectives on our understanding of different forms of pain expression and the social reactions of observers to various types of pain expression. Studies indicate that pain expression is governed by both automatic (unintentional, reflexive) and controlled (intentional, purposive) neuroregulatory systems. Reciprocal mechanisms in observers responsible for automatic (unintentional, reflexive) and controlled (intentional, reflective) reactions also appear important. Observers appear more likely to display immediate "visceral", emotional reactions to unintentional, reflexive expression, whereas controlled expression characterized by purposive~~, articulated~~ behaviour appears more likely to elicit ~~contemplative~~ reflection on the nature and origins of the person's pain. This review summarizes ~~pertinent~~ research within the context of a theoretical model for understanding how pain is perceived in others.

Perspective: People attempting to understand another person's pain may have access to the person's spontaneous behavioural reaction as well as verbal report and other purposive communications. The former instigates reflexive and emotional reactions whereas the latter tends to be perceived as confounding expression of experience with response to situational demands.

Perceiving Pain in Others: Automatic and Controlled Mechanisms

Recognizing and interpreting the significance of pain expression in others can be of great importance to the suffering person and the person witnessing the other's distress. Various actions, including language, paralinguistic vocalizations, facial expression, body posture, and escape or avoidance behaviour, may signal pain to others. These events can command the attention of observers from perspectives of both self-interest and social beneficence (and sometimes malevolence). They permit recognition of potential danger and provide opportunity for harm avoidance at the same time as they allow appreciation of what is happening to the person in pain, perhaps leading to provision of ~~care[37]~~care[45, ~~33~~41, ~~80~~92]. The adaptive value of responding to pain in others is embedded in the evolutionary history of humans and ancestral ~~species[6]~~species[7, ~~22~~27, ~~24~~30,87, ~~78~~90]. Despite its importance, the study of the social transaction initiated by pain expression is not well ~~developed[70]~~developed[80,82, ~~79~~, 91] although it is fundamental for understanding pain assessment in research and clinical ~~practice[72]~~practice[83].

Recent developments in clinical, cognitive and behavioural sciences as well as in social neuroscience can provide new perspectives on our understanding of different forms of pain expression and the social reactions of observers. Studies indicate that pain expression is governed by both automatic (unintentional, reflexive) and controlled (intentional, purposive) neuroregulatory ~~systems[35]~~systems[43]. Reciprocal mechanisms in observers responsible for automatic (unintentional, reflexive) and controlled (intentional, reflective) reactions also appear important. This review summarizes research within a theoretical model of how pain is perceived in others.

The Background

Tapping into the pain experience of another through use of painful expression is a challenging task. Expression can only partially represent the complexity of the subjective experience; hence, they are not equivalent[~~or isomorphic16~~26, ~~35~~43, ~~47~~55, ~~48~~56, ~~75~~86]. At the neurobiological level of analysis, different systems are associated with pain experience and expression. Studies of sensory and affective features of

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pain experience have focused upon afferent nociceptive and neuropathic mechanisms and central ~~processing[11]~~ processing[15], whereas investigations of pain expression necessitate examination of systems responsible for language and efferent neuromotor regulatory ~~mechanisms[76]~~ mechanisms[80,88,~~70~~].

Operationalizing the distinction between pain experience and expression poses problems. From the research perspective, experience cannot be studied through other than some form of expression. Inevitably, understanding the pain experience of another requires inference. One can identify various cues to be important ~~in~~ for observer judgments in the behaviour of the person in pain (self-report, other features of vocalizations, facial activity, body activity, limb withdrawal, writhing, and other nonverbal behaviors). Other evidence such as~~can be important. For example,~~ the presence of precipitants of injury[~~42~~50,61], actual bodily injury, and physiological response to tissue stress or pathology[5] can also influence judgements. However, the presence and experience of pain are often poorly related to the nature and magnitude of tissue stress or damage[11]. The inferences and judgments of observers necessitate attention to the behavioural reactions of the person in pain.

The primary resources available for examining the subjective experience of pain are self-report and nonverbal expression, categories of pain response that are readily differentiated and usually identified as conceptually different. In tightly controlled studies, they can be highly ~~correlated[47]~~ correlated[55]; more typically they are only modestly correlated, with contextual factors determining the magnitude of the ~~relationship[48]~~ relationship[56, ~~61~~70].

In competent, well-motivated people, *self-report* can provide a valid estimate of pain. But the need for competence in cognitive functioning and the potential for biased responses reflecting sufferer expectations and needs cannot be ~~ignored[43]~~ ignored[51, ~~69~~78]. The individual's perception of optimal performance and outcome in a given setting appears crucial and determines self-presentation. Those *assessing* the person for pain also may bias self-report by providing cues as to what level of report is expected or appropriate. Thus, self-report must be recognized as representing some combination of expression of personal experience and a response to an appraisal of the immediate situation.

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Nonverbal expression typically is endorsed as important when infants, young children, seniors with dementia, or others with communication limitations are unable to provide self-~~report~~[13]report[17], [38~~46~~]. However, nonverbal assessment is also important in everyday and clinical social discourse. Nonverbal expression typically adds context and meaning to language and can be perceived as more credible than self-report because it is not as subject to conscious control as the use of language[67]. But similar to self-report, nonverbal expression is not exclusively reflexive. It also confounds subjective experience and situational demands. Nonverbal expression is sensitive to ~~audiences~~[46]audiences[54], ~~71,~~ ~~60~~69, 81, ~~74~~85. People also can be reasonably successful in suppressing or exaggerating nonverbal pain ~~expression~~[21]expression[26], ~~40~~48, ~~36~~44, ~~50~~58, in accordance with perception of situational demands, thereby again confounding spontaneous with socially predicated expression. It is not surprising that observers, clinicians or otherwise, experience difficulties in determining whether either self-report or nonverbal behaviour represent manifestations of pain experience or reactions to self-serving or situational demand biases.

We propose an alternative classification that distinguishes between automatic, reflexive features of the response to pain, perhaps best illustrated by the protective nociceptive flexion ~~reflex~~[29]reflex[36], ~~89~~, and expressions of pain that reflect higher levels of central processing or purposive, deliberative control. Automatic reactions, whether in response to pain or other life events, tend to be sufficiently transparent so as to signify their direct meaning, and include "screaming in pain, laughing with joy, and growling with anger"[~~52~~60], (p. 29). Controlled, intentional expression is typified by the use of language for self-report purposes but also would include integrated sequences of instrumental motor ~~activity~~[35]activity[43], [~~48~~56]. The distinction is important because observers are disposed to attributing causes to other persons' ~~actions~~[39]actions[47], [~~51~~59]. Reflexive activity is considered to have quite different functional implications than activities that are suggestive of deliberate intention and executive control. Complexity is added by the reality that although pain behaviour may be unintentional (e.g., facial expression, or even

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nociceptive pain reflexes), it ~~is~~ can be controllable to a certain extent (e.g., inhibiting facial expression, exaggerating withdrawal reactions, etc.)[~~44~~52, ~~59~~68, 71].

The distinction between systems that are automatic, on the one hand, or subject to processing and control, on the other, also characterizes observer reactions. Witnessing others reacting to acute painful events is capable of instigating immediate "visceral" or gut level emotional ~~experiences~~[~~12~~]experiences[16]. The rapidly unfolding social neuroscience literature on cerebral correlates of witnessing others in painful distress documents the brain states to be ~~observed~~[~~42~~]observed[50, ~~54~~63, ~~64~~73]. These automatic, uncontrollable reactions are accompanied by immediate attention and parallel controlled reflective appraisal of the nature of the other person's situation, as well as attention to likely sources of the activity observed, as the observer seeks to understand what is happening to the other person.

The theoretical distinction between two major observable behavioural sources of information concerning another person's pain experience and two major patterns of reacting to others in pain arises from theoretical and empirically derived models of information processing implicating at the extremes automatic and controlled mechanisms, with these interrelated and operative in varying ~~degrees~~[~~53~~]degrees[62, ~~27~~34]. The proposition that human performance results from an interplay between automatic and controlled processing of ~~information~~[~~63~~]information[72] is predicated upon the understanding that in complex environments attention must be guided to process critical stimuli, yet other routine, well rehearsed and overlearned activities are executed repetitively without demands on attention. ~~yet other vegetative and well rehearsed actions occur without direction.~~ It has been applied to understanding social interaction phenomena in other ~~contexts~~[~~68~~]contexts[77, ~~3~~ 3] including study of such phenomena as automatic stereotype ~~activation~~[~~2~~]activation[2, ~~10~~ 12].

The following elaborates on this distinction as it contributes to understanding how those experiencing pain react and how observers respond to different forms of pain display.

Automatic and Controlled Features of the Behaviour of the Person in Pain

Systematic differences in the categories of painful expression set the occasion for variation in how observers perceive and respond to the person in pain.

Unintentional expressions of painful experience. Automatic pain manifestations are involuntary, spontaneous, triggered, stereotyped, predisposed sets of behavioural reactions elicited by noxious stimuli. They accompany but do not wholly or exclusively represent the sensory, affective and cognitive features of pain. From a physiological perspective, they are the somatomotor features of the coordinated central, hormonal, and autonomic response to tissue insult that have the relatively distinctive character of preparing the person to defend against tissue damage~~, in all its complexity~~.

In considering types of automatic behaviour it is useful to distinguish between observable actions that are directly protective, because they permit escape or avoidance of sources of pain, and those that are indirectly protective because they communicate distress to others, thereby eliciting their protective interventions[~~70~~80]. The former are represented by withdrawal reflexes and assuming guarded ~~postures~~[~~45~~]postures[53]. They act largely outside conscious awareness and deliberation. Communicative actions can also be reflexive or automatic. Infant behavioural reactions to painful events are reasonably seen as evolved protective behaviour, with control only emerging later on in ~~infancy~~[~~18~~]infancy[23, ~~34~~42, ~~52~~60]. During the earliest moments and months of life, some of the protective behaviour is primarily in the form of social communication, for example, crying or facial expression, thereby informing parents and other adults potentially able to intervene with sources of distress and/or ~~danger~~[~~34~~]danger[42].

Many communicative and other protective actions are reasonably construed as biologically prepared and unlearned. In older children and adults, continuity and stereotypy in various manifestations of pain can be ~~observed~~[~~18~~]observed[23]. Features of facial expression, paralinguistic qualities of speech, guarded behaviour and protective posture would appear to satisfy criteria for unintentional signs of pain, i.e., they are reflexive, display striking structural and functional consistency across the life span, the person largely is not ~~cognizant~~ aware of them, but they can be controlled to a certain extent. Criteria for automatic actions, as defined by Moors & De Houwer[62] include processing at

a relatively non-conscious level, efficiency in terms of not requiring effortful processing, absence of a formulated goal, and being purely stimulus driven ~~(see criteria for the automatic/controlled distinction in Moors & De Houwer[53]).~~ Concerning observable actions relevant to social communication, facial expression is typically the most salient and instructive for the ~~observer[19]~~observer[24, ~~6~~170, ~~78~~90]. A relatively stereotyped facial display of pain has been identified that is distinguishable from ~~other~~non-noxious emotional ~~and other~~ states, both behaviourally, in the judgments of ~~others[65]~~ others[74] and in observer brain states ~~observed~~ documented through neuro-~~imaging[64]~~imaging[73], but other socially relevant actions may be identifiable, for example, cry and paralinguistic qualities of speech.

Automatic responses are expected to be relatively stimulus driven and independent of attention and contextual ~~influence[53]~~influence[62]. However, it is clear that emotional and cognitive factors may modify reflexive responses, for example, stress induced analgesia is capable of diminishing reflexive withdrawal responses in rats and ~~humans[28]~~ humans[35] and negative emotions can potentiate startle in ~~humans[5]~~humans[6]. While facial expression is a candidate for relatively immediate responding without conscious attending to the display, it is context-sensitive and linked to environmental demands. For example, presence of an audience of strangers tends to inhibit facial expression of ~~pain[46]~~pain[54], although children who engage in high levels of catastrophizing appear to indiscriminately display pain and are less likely to suppress pain ~~expression[75]~~expression[86]. Furthermore, automatic responses are to some extent subject to voluntary control, for example, ~~suppression[62]~~ suppression[71] or ~~enhancement[40]~~enhancement[48]. As children mature, originally automatic manifestations of pain come at least partially under voluntary control. For example, the essentially reflexive crying of the neonate becomes more of a speech ~~act[20]~~ act[25] and children learn to suppress pain expression in the presence of peers when negative reactions are ~~anticipated[50]~~anticipated[58]. Control can be achieved over facial displays of ~~pain[17]~~pain[22], including both exaggeration and suppression of the display; however, the exaggerated display differs from the genuine display in subtle ~~ways[41]~~ways[49], and neither faking nor suppression of facial displays are wholly ~~successful[36]~~successful[44, ~~58~~67].

Intentional expressions of painful experience. These can be construed as typically deliberate, conscious, and coordinated by executive functions[1]. The latter are implicated when complex cognitive sub-processes such as planning, anticipation, and decision-making become engaged. The use of language appears to best illustrate controlled expression of pain. It is noteworthy that complex, coordinated or innovative responses to situational demands can come to be relatively automatic, in this instance enacted without deliberation, when thoroughly well rehearsed in particular situations[3, ~~53~~62].

Understanding controlled expression would appear to be more important to understanding human pain expression, although continuity in controlled expression across primate species is ~~evident[22]~~evident[27]. Interaction between automatic reactions and controlled expressions would be expected, with the latter coming to modulate the former in the course of human ontogeny, but there are limits to the extent that automatic expressions can be over-ridden by conscious control.

Automatic and Controlled Features of Perceiving Pain in Others

Cues related to pain in another person have the potential to influence observer perception of pain, some as a result of automatic activation, with others acquiring meaning only through conscious deliberation and executive processing. The act of perceiving others in pain has been characterized in a theoretical model of pain empathy as the product of both bottom-up and top-down ~~variables[30]~~variables[38, ~~31~~39]. "Bottom-up" information is derived through perception of the actions of the person manifesting pain. The concept refers primarily to automatic reactions to the painful reactions of others and would implicate the detection of pain. This is appraised and achieves significance for the observer through utilization of "top-down" information reflecting application of the beliefs, expectancies, attitudes and biases of the observer, a process characterized by greater levels of controlled processing..

Automatic Reactions. These are characterized as reflexive, intuitive, automatic "gut feelings" evoked by the pain reactions of others. These "visceral" reactions are reasonably construed as more ancient in their evolutionary origins, conserved across phyla by virtue of their functional advantages in warning, motivating and protecting progenitors, thereby increasing reproductive fitness. There would

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appear to be automatic processing of cues through biologically prepared innate, unconditioned feature detectors that give rise to reflex-like responses. Current brain imaging studies of biological reactivity demonstrate a powerful and immediate biological impact of the experience of ~~observing~~ witnessing others in pain on ~~observers[7]~~ observers[8, ~~23~~28, ~~42~~50, ~~54~~63, ~~64~~73, ~~67~~76].

Reactions are influenced by contextual factors (e.g., setting and social cues, and characteristics of the person in ~~pain[15]~~ pain[19,29, ~~32~~40, ~~49~~52, 57]. The relationship between the observer and the person in pain can dictate~~s~~ the reaction and perhaps commitment to the person in pain. This is evident in both behavioural and brain imaging studies ~~(e.g., professional, family, stranger)~~. For example, judgements of pain in infants differ systematically across parents, nurses and ~~pediatricians[56]~~ pediatricians[65] and the perceived fairness of others expressing pain were found to modulate empathic neural ~~responses[66]~~ responses[75].

Automatic reaction patterns would not be restricted to reflexive or autonomic activation, but could include automatic instigation of thoughts, beliefs and biases. Inherent sensitivity would appear to involve matching of stimulus input to prepared schema, thereby instigating unconditioned and coordinated reaction patterns. In turn these reactions would be amenable to conditioning and yield templates that guide automatic evaluation of perceived threat and reactions thereafter[4, ~~9~~10, ~~55~~64, ~~73~~84].

Controlled processing. When an observer attends to another person's plight, automatic reactions would be accompanied by efforts to understand and plan actions suitable to the situation[77]. There is a need to know not only what is happening to the individual but also why this is happening, what sequence of events led to the person's painful distress, and what the person could do, or what the observer could do to resolve the situation. Problem-solving, memory, judgment, attitudes and biases are likely to be implicated. ~~When an observer attends to another person's distress or situational demands dictate attention to the person's plight, a range of cognitive and affective processes are implicated in decision-making, including memory, problem-solving, judgment, various heuristics, attitudes and biases.~~ This higher level of neuroregulatory information processing would implicate executive functions[52,79].

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Automatic processing is reasonably effortless or passive, with controlled processing more likely to predominate when conflicting or disconfirming evidence is present and active ~~processing~~ deliberation is necessary to resolve ~~the~~ contradicti~~o~~ng information and demands[77]. Both unconscious processing and consciously guided conceptual-level processes would come into play, ~~deploying propositional knowledge to~~allowing observer knowledge to refine judgements ~~of~~ about the nature of the other's distress. Thus, elements of automatic processing are implicated in controlled reactions. There would be consideration of risks and appraisal of strategies for harm avoidance for ~~both oneself~~oneself and the person in ~~pain~~[80]pain[92, ~~33~~41]. Beliefs (true and false), expectations, or prior knowledge would have an impact, as would ~~the capacity for higher level decision making,~~ the capacity for self-regulation of emotions, and empathy. Reasoned appraisal should lead to a broad understanding of the other's experience, its origins and likely outcomes. While one can distinguish between bottom up and top down processes, they operate in parallel, with conscious processing persisting longer than the immediate spontaneous reaction[38].

Interactions between controlled and automatic processing in sufferers and observers

Observer reactions appear to vary systematically with the different categories of pain expression~~.~~ in the person being observed (see Figure 1 for a schematic representation of the interaction). Expression of pain indicative of automatic reactions to situations (reflexes, emotional reactions) instigates different reactions in observers than controlled reactions indicative of ~~personal agency~~planned, goal-directed behavior. Thus, different manifestations of pain would not be equivalent to others in their capacity to instigate particular reaction patterns ~~(see Figure 1)~~.

Observer reactions to automatic expression. These stimulus driven reactions would be intuitive and immediate. The observer need only be passive, but the impact appears potent. Facial displays depicting vivid emotional expression have been found to be particularly effective in commanding attention and to be prepotent in their impact[37]. ~~This is the default mode.~~ Little cognitive participation in the emotional reaction would be expected, although efforts to understand what is happening would also

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be immediately instigated (controlled reactions). In the primordial world, through to the present, observing these reactions in others would instigate a sense of personal danger with fear for the other person a subordinate ~~response[37]~~ response[45,73,~~80~~92].

It is noteworthy that the cues most likely to instigate emotional processing fall in the domains of raw visual or auditory experience. These sensory modalities are also basic to reading and speech but these human capabilities rely extensively upon more complex, learned cognitive skills. Linguistic and literacy skills come to be acquired slowly during development of the child, signalling the complexity of the cognitive processes engaged when language or written communications are used to convey information about painful states. The semantic features of self reports rely upon symbolic/linguistic mediation, or top down processing. However, paralinguistic ~~or prosodic~~ qualities of speech convey the emotional or mood status of the speaker and some forms of language (e.g., ~~cuss~~ swear words, particularly evocative language used by authors or patients, or poetry) are capable of instigating immediate, vigorous visceral ~~reactions[57]~~ reactions[66]. Language also has a capacity to automatically instigate certain automatic appraisals of events from memory when objects of attitudes ~~objects~~ are encountered, for example, ~~prejudices[25]~~ prejudices[32, ~~26~~33].

Observer r~~R~~eactions to intentional expression. While also immediate, these observer reactions would be of longer duration, as decoding and appraisal ~~the~~ of information ~~and the appraisal~~ would require complex and effortful[62] cognitive processing. This would require attentional and problem solving resources, as effort was expended to sort out competing interpretations. The subtle nuances of language are important in differential diagnosis as alternative explanations of signs and symptoms are explored. In everyday social experience, when pain complaints are made, there must be similar searches among competing explanations of the origins of the individual's complaints. Listeners are likely to appreciate that the account is determined by both internal states being described and the speaker's appraisal of the situation.

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The suffering person's capacity to control expression would make the expression more difficult to understand, more ambiguous as to its origins, and less readily interpreted as the immediate product of specific stimuli. It seems less likely that controlled reactions alone would be capable of triggering~~, or instantiating,~~ the same full empathic emotional reactions provoked by automatic bottom up stimuli, although, as discussed above, skilled narrators or writers seem capable of generating verbal scenarios capable of provoking resonant reactions in others. Patients often work hard to present convincing cases of the gravity of their condition~~make the objective/rational assessments less an intellectual experience and more an emotional drama[77][89]~~. Given awareness of the potential for voluntary control, risks of fabrication may be appraised.

People presenting with pain invariably are subject to careful appraisal by ~~others[14]~~others[18, 82]. While trust seems the accepted norm and clinicians are routinely enjoined to believe patient self-report of pain, optimal care giving and prudent stewardship of resources require judgements about the legitimacy of the representations of the person in distress. Medically unexplained pain appears particularly susceptible to doubts about the credibility of complaints. Patients for whom there is no scientific explanation of their pain are described as at risk of being marginalized from meaningful professional care and treatment[14]. In the absence of medical evidence for tissue damage or stress, examiners must rely upon symptom complaints; hence, credibility is likely to be questioned. Universal propensities to detect cheaters have been postulated by evolutionary biologists to account for careful scrutiny of others in social transactions[13,20,48,49,90]. Prkachin, Solomon and ~~Ross[61]~~ Ross[70] observed that suspicions surrounding the motivations of the patient impacted pain judgments during clinical decision making. Enjoining health care practitioners to utilize and believe self-report to some extent appears to be founded upon implicit recognition of the limited effectiveness of self-report in generating resonant feelings in observers.

Conclusions

Understanding the process whereby observers infer the presence and nature of pain in others requires an appreciation of the interaction between the expressive behaviour of people manifesting pain

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Comment [KD11]: Craig, K.D. & Badali, M.A. (2004). Introduction to the Special Series on the Detection of Pain Deception and Malingering. *Clinical Journal of Pain*, 20, 377-382.
Cosmides L, Tooby J: Cognitive adaptations for social exchange. in Barkow JH, Cosmides L, Tooby J (eds.): The Adapted Mind: Evolutionary psychology and the generation of culture. New York NY, Oxford University Press, 1992, 163-228

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and the multiple affective and cognitive systems regulating the reactions of observers. The distinction between automatic and controlled information processing systems appears valuable in interpreting both the reactions of people in pain and of observers whose attention is directed to understanding the experience of the person in pain. The appraisal of the observer appears driven by both self interest and altruistic concern. The experience of pain in others can alert observers to risk of personal danger, as well as the potential that the other person requires care. Spontaneous (automatic) expressions of pain are more likely to instigate strong empathic reactions in observers, whereas controlled expressions that lack spontaneity are more likely to ~~lack~~ lead to questions about credibility. Understanding the complexities of the interaction between persons in pain and those reacting to them is likely to enhance delivery of care.

Figure 1:

		EXPRESSION OF PERSON IN PAIN	
		Automatic (reflexive escape, facial grimaces, cry)	**Controlled** (deliberate self-report, purposive actions)
OBSERVER REACTION	**Automatic** (involuntary, gut level)	LIKELY: involuntary emotional responses	LESS LIKELY (but possible)
	Controlled (contemplation, active decision-making)	PARALLEL: including delayed reflection	LIKELY (reflection, question credibility)

Figure 1. A representation of the probable reactions of observers to automatic and expressive displays of people in pain. Automatic expression is likely to instigate automatic, emotional reactions, as well as parallel cognitive appraisal. Controlled expression is less likely to evoke powerful automatic/emotional reactions in observers, but will instigate reflection and interest in various sources of the expression.

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Figure Legend

Figure 1. A representation of the probable reactions of observers to automatic and expressive displays of people in pain. Automatic expression is likely to instigate automatic, emotional reactions, as well as parallel cognitive appraisal. Controlled expression is less likely to evoke powerful automatic/emotional reactions in observers, but will instigate reflection and interest in various sources of the expression.

*** Revision Notes**

Dear Dr. Gebhart:

Thank you for the opportunity to submit a revision of our manuscript "Perceiving pain in others: Automatic and controlled mechanisms". We very much appreciated the recommendations and observations of the reviewers and have revised the paper in accordance with all the suggestions, excepting two observations. We have detailed the various changes in the following, including explanations for deciding to not follow through on two suggestions (see comments on Reviewer #2 observations below).

Your editorial decision letter:

> "References 31, 32, 33 and 80 are listed as "in press." If possible, these should be updated with publication information."

These papers have all been published and complete publication information is now provided.

Reviewer #1:

1) "Accessibility to average reader--The manuscript contains a fair amount of psychological terminology which may not be familiar to the average reader of the journal. This is unfortunate since it reduces its potential impact on the field. The authors should consider attempting to reframe some of the terminology to deal with this problem."

We have carefully reviewed the paper for jargon not that accessible to others and attempted to make the text clearer. Words or expressions such as the following were removed or explained in clearer language: isomorphic, cognizant, heuristic, prosodic, deploying propositional knowledge, personal agency, instantiating.

2) "Citations--Many of the assertions made do not carry citations with them. It would be good to increase the number of citations for readers who wish to examine the evidence underpinning these assertions."

Again we reviewed the paper in an effort to establish where we had failed to provide adequate citations. The following 12 papers have now been referenced in addition to the 80 in the original paper. We could add more, but believe the additional references would be redundant to those provided.

Vogel, G. (2004). The evolution of the golden rule. *Science, 303*, 1128-1131.

Tait RC, Chibnall JT, Kalauokalani D: Provider judgments of patients in pain: Seeking symptom certainty. *Pain Medicine* 10: 11-34, 2009

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3) "Page 10--Consider giving more detailed examples of the range of cognitive and affective processes involved in decision making. This would help readers much better understand the potential influence of memory, problem solving, judgement, heuristics, and biases."

This component of the paper addresses the nature of the "Controlled Processes" instigated by viewing others in pain. We have contrasted automatic and controlled processes in several places in the paper. In this section we revised the statement to the following in the interests of clarifying observer processing that is more effortful in the interests of making sense of the suffering person's painful distress:

"When an observer attends to another person's plight, automatic reactions would be accompanied by efforts to understand and plan actions suitable to the situation[77]. There is a need to know not only what is happening to the individual but also why this is happening, what sequence of events led to the person's painful distress, and

what the person could do, or what the observer could do to resolve the situation. Problem-solving, memory, judgment, attitudes and biases are likely to be implicated."

4) "Page 11--Explain what is meant by the term "personal agency" in the sentence that ends: "controlled reactions indicative of personal agency". Readers may not understand this. Also, describe what is meant by "default mode" in the next paragraph."

The term personal agency clearly is psychology jargon. We replaced it by "planned goal-directed behavior". The sentence "This is the default mode." is redundant, hence deleted.

5) Page 12--Emotional drama--I think many investigators in this area would object to the sentence "Patients often work hard to make the objective/rational assessments less an intellectual experinece and more an emotional drama." When one thinks of the large number of people who experience and report on their pain, this statement seems like an over-simplification. It does not seem to adequately capture the research literature in this area. I would recommend dropping this sentence or qualifying it more.

We agree with the reviewer and have replaced the sentence with "Patients often work hard to present convincing cases of the gravity of their condition[89]."

Reviewer #2:

1 "It would be helpful to have some brief elaboration of how Moors & de Houwer distinguish automatic and controlled processing, rather than only the reference, to help readers."

Good observation and readily, briefly accomplished. We added Moors and de Houwer's criteria for automatic processing as per the following sentence:

"Criteria for automatic actions, as defined by Moors & De Houwer[62] include processing at a relatively non-conscious level, efficiency in terms of not requiring effortful processing, absence of a formulated goal, and being purely stimulus driven."

2 I'd have liked to see comments on hypotheses around in the field at present, particularly those informing empirical work, such as that simulated pain expression is as good as controlled pain expression for studying observers' reactions (Rainville and others); that pain behaviour, including facial expression can be divided into protective and communicative behaviours (Sullivan and colleagues), or is this distinction not in the behaviours but in their interpretation by observers; or that there might be priority processing for apparently inauthentic expression by a cheater detection algorithm (Williams and colleagues).

Concerning the first point, we have published a number of studies examining the proposition that "simulated pain expression is as good as controlled pain expression for studying observers' reactions (Rainville and others)". In brief summary, people do well in

simulating pain expression (Poole, G.D., & Craig, K.D. (1992). Judgments of genuine, suppressed and faked facial expressions of pain. *Journal of Personality and Social Psychology: Interpersonal Relations and Group Processes, 63*, 797-805.), but there are subtle differences (Craig, K. D., Hyde, S. A., & Patrick, C. J. (1991). Genuine, suppressed, and faked facial behavior during exacerbation of chronic low back pain. *Pain, 46*, 161-172. Hill, M.L., & Craig, K.D. (2002). Detecting deception in pain expressions: The structure of genuine and deceptive facial displays. *Pain*, 98, 135-144.) that are discernible to observers (Hadjistavropoulos, H.D., Craig, K.D., Hadjistavropoulos, T., & Poole, G.D. (1996). Subjective judgments of deception in pain expression: Accuracy and errors. *Pain, 65*, 247-254.). Observers can be taught to distinguish simulated displays with difficulty and not all that successfully (Hill, M.L., & Craig, K.D. (2004). Detecting deception in facial expressions of pain: Accuracy and training. *Clinical Journal of Pain*, 20, 415-422.). Skill in dissimulating pain appears acquired, as children do not do as well as adults (Larochette, A.C, Chambers, C.T., & Craig, K.D. (2006). Genuine, suppressed and faked facial expressions of pain in children. *Pain*, 126, 64-71.). We have addressed the complexities of detecting simulation in several review chapters, e.g., Craig, K.D., Hill, M.L., McMurtry, B. (1999). Detecting deception and alingering. In A.R. Block, E.F. Kramer, & E. Fernandez (Eds.), *Handbook of Chronic Pain Syndromes: Biopsychosocial Perspectives*. pp. 41-58. New York: Lawrence Erlbaum. Our work with Pierre Rainville (Simon, D., Craig, K.D., Gosselin, F., Belin, P., & Rainville, P. (2008). Recognition and discrimination of prototypical dynamic expressions of pain and emotions. *Pain*, 135, 55-64. Simon, D., Craig, K.D., Miltner, W.H.R., & Rainville, P. (2006). Brain responses to dynamic facial expressions of pain. *Pain*, 126, 309-318.) using actors trained to simulate pain and a range of emotional displays was complicated by the findings we and others have generated indicating that there are subtle differences between genuine and dissimulated displays and we used a number of training strategies and validity checks to overcome the problem. We did not address the issues in detail in the paper submitted, but the basic substance of the issues was described, for example, "Control can be achieved over facial displays of pain[22], including both exaggeration and suppression of the display; however, the exaggerated display differs from the genuine display in subtle ways[52], and neither faking nor suppression of facial displays are wholly successful[44, 67]."

The second point ("that pain behaviour, including facial expression can be divided into protective and communicative behaviours (Sullivan and colleagues), or is this distinction not in the behaviours but in their interpretation by observers") was addressed in the paper. For example, the primary paragraph addressing this begins with "In considering types of automatic behaviour it is useful to distinguish between observable actions that are directly protective, because they permit escape or avoidance of sources of pain, and those that are indirectly protective because they communicate distress to others, thereby eliciting their protective interventions[80]" We could provide many additional references, including those to our own work using the distinction, but reference

80 effectively covers the field and includes many additional references that demonstrate the validity of the distinction. We would argue that the distinction can be made independent of the judgment of the observer.

The third point ("that there might be priority processing for apparently inauthentic expression by a cheater detection algorithm (Williams and colleagues") lies at the heart of much evolutionary biology/psychology theorizing and study in discussion of such topics as reciprocal altruism and psychopathic behavior. We acknowledge the point in adding the following statement "Universal propensities to detect cheaters have been postulated by evolutionary biologists to account for careful scrutiny of others in social[13,20,48,49,90]", but hesitate to provide a more complete analysis. Papers referenced do provide the extensive analysis.

Final observations, following, have been addressed:

On p 9 I don't understand the sentence: Automatic processing can be (Bottom up or stimulus driven processes). What is meant by the brackets and underlining?

Reference 7 I think should be to Neuroimage, not NeroImage!
And reference 15 has an odd format for the date.

There are additional minor wording changes that improve the writing.

Thank you for the opportunity to revise and resubmit.

Sincerely,
Ken

Kenneth D. Craig,
Professor of Psychology