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A Biopsychosocial Formulation of Pain Communication

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Abstract

We present a detailed framework for understanding the numerous and complicated interactions among psychological and social determinants of pain through examination of the process of pain communication. The focus is on an improved understanding of immediate dyadic transactions during painful events in the context of broader social phenomena. Fine-grain consideration of social transactions during pain leads to an appreciation of sociobehavioral events affecting both suffering persons as well as caregivers. Our examination considers knowledge from a variety of perspectives, including clinical health psychology, social and developmental processes, evolutionary psychology, communication studies, and behavioral neuroscience.

Keywords: communication studies, pain, neuroscience, theoretical model

Pain is a universal form of human distress, with acute and chronic pain constituting widespread public health problems (Ng, Dimsdale, Sharagg, & Deutsch, 1996; Owen, McMillan, & Rogowski, 1990; Smith, Shah, Goldman, & Taddio, 2007; Todd, Samaria, & Hoffman, 1993) . Point prevalence estimates of persistent pain in population samples range between 7% and 64%, depending on survey methodology and population studied (Perquin et al., 2000; Petersen, Brulin, & Bergstrom, 2006). Pain affects people of all ages (Crombie, Croft, Linton, LeResche, & Von Korff, 1999) who live in the community (Jones & Macfarlane, 2005) and in health care facilities (e.g., Proctor & Hirdes, 2001). There are many well-demonstrated adverse consequences of persistent pain (Rashiq, Schopflocher, Taenzer, & Jonsson, 2008), including a destructive impact on psychological and physical wellbeing, reduced capacity to maintain employment, and deteriorating social functioning (e.g., Closs, Staples, Reid, Bennett, & Briggs, 2008; Harris, Morley, & Barton, 2003; Hummel, Lu, Cummons, & Whiteside, 2008).

The high prevalence of unsatisfactorily treated pain demonstrates how refractive pain has been to typical clinical care, despite considerable basic and clinical science research effort and a substantially better understanding of the biology of pain that has emerged in recent decades (McMahon & Koltzenburg, 2005; Melzack & Wall, 1988). Unfortunately, pain often remains unrecognized, poorly assessed, under-estimated, under-treated, or inadequately treated (Craig, 2009; Melzack, 1990b). A better understanding of the biology of pain is vital, but inadequate to the challenges of pain control in the absence of careful consideration of psychosocial factors which have been shown to play an important role in the determination of pain intensity and pain-related outcomes (e.g., Clay et al., 2010). This has led to calls to more widely embrace the dimensions of the biopsychosocial model of pain (Brennan, Carr, & Colusins, 2007; Gatchel, Peng, Peters, Fuchs, & Turk, 2007).

The biopsychosocial perspective on pain has been recognized as necessary for research and practice if the full scope of pain is to be understood or care is to be effectively delivered to individuals in need (e.g., Engel, 1977; Gatchel et al., 2007; Robinson & Riley, 1999; Turk & Okifuji, 2002). Figure 1 depicts the intersecting dimensions of biological, psychological and social determinants as they contribute to personal wellbeing. Substantial evidence supports this approach to pain (Gatchel et al., 2007; Turk & Okifuji, 2002), although attention to biological phenomena has outweighed consideration of other factors.

This paper provides a detailed framework for understanding the numerous and complicated interactions among psychological and social determinants of pain through detailed examination of the processes of pain communication. The focus is on an improved understanding of immediate dyadic transactions during painful events in the context of broader social phenomena including institutional, organizational and public policy. Fine-grain consideration of social transactions during pain leads to an appreciation of sociobehavioral events that must be understood in both the suffering person and caregivers. Pain communication is an extremely common component of the pain experience that has evolved along with language and other non-verbal signals within the context of human society. In this paper pain communication is examined through a variety of perspectives, including clinical health psychology, social and developmental processes, evolutionary psychology, communication studies, and behavioral neuroscience.

Gate Control Theory, Biopsychosocial Formulations and Pain Communication

Since the 19th Century, vigorous and widespread research efforts have led to advances in our understanding of the biology of pain. In the mid 20th Century, formulation of the Gate Control Theory of Pain (Melzack & Katz, 2004; Melzack & Wall, 1965) effectively moved researchers and clinicians from a narrow biophysical focus on pain as a sensory experience to a

novel, unifying understanding of pain as a complex psychological phenomenon modulated by peripheral and central nociceptive systems and amenable to control through diverse biomedical and psychosocial interventions (Asmundson & Wright, 2004; Merskey, 1998). The past 40 plus years have seen substantial elaboration of our understanding of the facilitatory and inhibitory mechanisms which modulate nociceptive processes (Basbaum & Fields, 1984; Julien, Goffaux, Arsenault, & Marchand, 2005; Julien & Marchand, 2006; Melzack, 1990a), thereby providing a neurophysiological basis for conceptualizing the biological substrates of psychological (cognitive, affective and sensory) and environmental (physical, family and cultural) determinants of pain experience and expression. The roles of intrapersonal and interpersonal determinants of pain experience became recognized in mainstream scientific conceptualizations of pain. Explanations at the level of biology describe mechanisms and constraints governing functional adaptations to environmental demands. Adaptive behavior in humans is conceptualized here in terms of these psychological and social adaptations rather than through reductionistic descriptions of the molecular biological processes that evolved to support adaptive behavior.

Pain is now acknowledged as a complex psychological experience, with the widely endorsed definition of pain promulgated by the International Association for the Study of Pain describing it as "An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (International Association for the Study of Pain, 2005). One notable feature of this definition is rejection of the position that pain is caused by tissue stress or damage, with the observation that it is associated with damage, leaving room for multiple causes, mediators, and moderators. While nociception refers to the neurophysiological translation of events that stimulate nociceptors (peripheral receptors that respond to potentially damaging stimuli) and are capable of being experienced as pain, pain represents a perceptual process associated with conscious awareness that will vary with the

organism, but in typical adult humans is associated with meaning, appraisal, learning, and emotional reactions (Gatchel et al., 2007; Hale & Hadjistavropoulos, 1997; Melzack & Casey, 1968). Explication of psychological mechanisms has resulted in novel interventions for both acute and chronic pain, with substantial evidence supporting their use in the control of pain (e.g., Jensen, Turner, & Romano, 2001; Morley, Eccleston, & Williams, 1999; Nicholas, Wilson, & Goyen, 1992).

A number of biobehavioral perspectives on pain have emphasized psychological and behavioral processes (e.g., Vlaeyen & Linton, 2000; Waddell, 1992; Waddell, 1998). We present some examples here. The operant model (Fordyce, 1976; Fordyce, Shelton, & Dundore, 1982) stressed the influence of reinforcement processes in the development and maintenance of pain behavior. As a second example, the Glasgow model of pain disability (e.g., Waddell, 1987, 1991, 1992) emphasized intrapersonal pain dimensions (i.e., affective, sensory, behavioral, and cognitive factors), as well as social factors. A broader biobehavioral perspective on pain (e.g., Turk, Meichenbaum, & Genest, 1983) proposed that both chronic and acute pain are consequences of the interaction among biological diatheses and specific physiological, behavioral, cognitive and social features of pain.

The central role of cognition has been recognized by most biopsychosocial conceptualizations of pain. For example, the negative consequences of rumination, magnifying the undesirability of the experience, and feelings of helplessness are core components of catastrophic thinking that diminishes recovery in the functioning of pain patients (Drahovzal, Stewart, & Sullivan, 2006; Sullivan, Martel, Tripp, Savard, & Crombez, 2006a).

Nevertheless, the focus has been upon *intrapersonal* processes, both biological and psychological, leaving the social dimensions of the biopsychosocial model relatively unexamined. Pain may largely be a private, highly personal, and subjective experience, but it

also has major social features. People rarely suffer pain in silence and its immediate and long-term behavioral consequences tend to be substantial and important to not only the individual but the community at large.   Central to understanding *interpersonal* features of pain is recognition that pain typically is experienced in complex social environments, with the person's distress manifestly obvious, often predicated upon the social setting, and reactions of others. Pain serves as an archetypal sign of threat and commands not only the attention of the sufferer (Eccleston & Crombez, 1999), but also, through behavioral manifestations, the attention of people in the social environment (Cano, Barterian, & Heller, 2008; Craig, 2004; Goubert et al., 2005; Hadjistavropoulos & Craig, 2002). Others' responses, in turn, have an important impact upon the pain experience and wellbeing of the person in pain (Chambers, Craig, & Bennett, 2002). It has been widely appreciated that linguistic and social skills are acquired in specific familial and ethnic contexts (Palermo & Chambers, 2005; Stanford, Chambers, & Craig, 2005) that enable the suffering person to realize the advantages of social caring and inteventions In sum, to date we have acquired a substantial understanding of pathologies, injuries and diseases, as sources of pain, and their impact on the host, both in terms of biology and subjective experience. Nevertheless, the contributions of environmental contexts in which pain is suffered have received relatively less formal study perhaps because it is widely assumed that their explanations (e.g., reinforcement concepts) are well established. Nonetheless, there are many important unanswered questions that would be suitable for formal investigation.

Accordingly, a comprehensive understanding of pain as a *social* phenomenon requires consideration of social or communicative (i.e. "expressive" and "receptive") features. The dynamic interplay between the individual and the social environment in which pain emerges determines exposure to pain, the experience of pain and suffering, pain expression, and related disability. The scope of this cannot be underestimated. The person's developmental history of

social interactions must be appreciated as having a formative impact on pain experience and expression (Craig, 1978). Some individuals, for example, may tend to only attend and interpret the cues that constitute pain expressions in determining whether or not to respond. Others, on the other hand, may also consider social standards and normative patterns in their responses to another's pain. There are a multitude of intrapersonal and interpersonal or contextual factors that might influence the extent to which a sufferer's pain becomes manifest socially, and hence, is expressed behaviorally. In a similar vein, both characteristics of the context and intrapersonal characteristics of the observer influence both attention to pain cues and interpretation of these pain cues, thereby having an impact upon caregiving behavior and the suffering person's ongoing distress (Goubert, Vervoort, Cano, & Crombez, 2009b; Goubert, Vervoort, & Crombez, 2009c; Hadjistavropoulos, Craig, Grunau, & Whitfield, 1997).

A General Communications Framework

Human communication research provides a basis for conceptualizing the impact of inter- and intra-personal factors on the experience of pain. Communication theorists distinguish three types of communication (Duck & McMahan, 2010). **Communication as action (or communication as "expression")** is where a message is sent <u>or</u> a message is received (e.g., a message left on a telephone answering machine or the blush of an embarrassed person). **Communication as interaction is** where a message is sent, received and interpreted, whether as intended or incorrectly (e.g., in everyday conversation; participants understand the literal meaning of one another's comments). **Communication as transaction** is where messages are exchanged but something other than the exchange of messages results (e.g., two people exchanging messages of agreement and a contract is transacted as a result; or a marriage ceremony where exchange of "I do" is not just a report of intent but transacts the wedding of one person to another). Transaction does not depend on accuracy, but also accommodates

transacted mistakes, such as a friendly remark that is taken as (transacts) an offence with consequences for the relationship.

All of the above are *categories* of communication, and, for example, transactive communication can include constative and performative acts in speech (Austin, 1962). These include *declaratives* ("I now declare you husband and wife", which is a remark that by itself transacts a change in status and reality) or *promises*, which are not simply verbal statements, but transact behavioral commitments to future courses of action. The key point here is that not all "communications" are created equal, and this point has great significance for the understanding of pain.

Conceptualizing the complex social processes associated with pain from the perspective of communication as a dyadic transaction is important because the consequences of pain communication could potentially be profound for both the observer and suffering person. The challenge is obvious in the study of pain as observers cannot know the state of the person in pain in all its complexity, particularly its sensory features (Goubert, Eccleston, Vervoort, Jordan, & Crombez, 2006). Nevertheless, pain research has utilized the three separate approaches to communication. There is a considerable literature focusing upon self-report (Schiavenato & Craig, 2010) and nonverbal expression (Craig, Prkachin, & Grunau, 2011) as manifestations of pain and observer response to both forms of expression is also of considerable interest (communication as action) (Craig, Versloot, Goubert, Vervoort, & Crombez, 2010; Tait, Chibnall, & Kalauokalani, 2009). When the person in pain effectively communicates distress, enabling the observer to understand the objects, feelings, thoughts and expressions of the suffering person, then pain is serving as interactive communication. When a physician and patient communicate interactively and the physician infers some underlying pathophysiological

process, provides a diagnosis, and commits to treatment, pain contributes to a transactive communication.

These distinctions, elaborated below, are important in understanding the nature of pain communication. The "expression" of pain and the reaction of an observer may be conceptualized as an action (encoding or decoding of the experience) or an interaction (the dyadic process). Studies of automatic/reflexive or controlled manifestations of pain (Hadjistavropoulos & Craig, 2002) exemplify investigation of communicative actions. Similarly, the automatic/reflexive and controlled reactions of the observer can be studied, for example, the gut reaction to another person's horrifying accident, or distrusting another person's report of pain (Craig et al., 2010).

Pain communication as an interaction concerns instances in which the observer correctly or incorrectly interprets the experience and intentions of the person doing the expressing. In fact, extensive research suggests that interpretation biases can operate when interpreting ambiguous cues, including facial expressions, particularly when observers are anxious (MacLeod & Cohen, 1993; Schofield, Coles, & Gibb, 2007). Errors reflect discordance between experience and expression in the person in pain and observer perception. Common errors include interpreting the reactions of an infant to tissue injury as signaling little more than reflexes (Eland & Anderson, 1977; Oberlander, Grunau, Fitzgerald, & Whitfield, 2002) and interpreting signs of anxiety and confusion as indicative of malingering during pain disability assessment (Craig, Hill, & McMurtry, 1999; Hill & Craig, 2002). Observers also may misattribute the intent of the message, or indeed mistake whether a message was intentionally sent. Winces, smiles, yelps or sharp intakes of breath can be laden with meaning for an observer when no such meaning was intended by the "sender".

A classic debate in communication studies concerns the extent to which the intent to communicate is a precondition for communication to occur (Watzalawick, Beavin, & Jackson, 1967). Eisenberg (2001), for example, asserted that true communication only occurs when there is intent to communicate on the part of one person (the sender) and an attribution of intentionality on the part of the observing person (the receiver). In contrast, Burke (1966) distinguishes between "motion" and "action". Motion is simply behavior without any thought or intent behind it. The classic example is the reflex behavior occasioned by a physician tapping one's knee with a rubber mallet. While this reflexive action conveys important information to the physician (as receiver), the patient (in this case an unknowing sender) has difficulty controlling the response. Thus, a motion by a sender can have meaning to a receiver. Despite the question of whether an unintended action, that conveys information to the observer can technically be considered communication, scholars of pain communication have systematically studied such actions (e.g., reflexive withdrawal, guarded postures, facial grimaces, and protective behavior (Craig, 2009; Prkachin & Craig, 1995). Utilization of these pain-related motions/actions is fundamental to understanding pain in persons incapable of formulating personal intent, such as infants (e.g., Grunau & Craig, 1987) or seniors with dementia (Hadjistavropoulos, LaChapelle, MacLeod, Snider, & Craig, 2000b; Kunz, Scharmann, Hemmeter, Schepelmann, & Lautenbacher, 2007). It would appear better to consider the perception of intentionality as only one possible, but not necessary, feature of pain communication.

Pain communications extend beyond those in which two people speak to one another in a common language. Speech typically implies reflective thought, anticipation, and intentionality. Pain communications of this type certainly are important and more complex because it requires use of symbols, for example, words. They are meaningful to the extent that they are understood

and shared by the sender and receiver. Speech typifies actions requiring formulation of intent and controlled execution to fulfill communicative roles. They are comprehensible in a motivational framework that accepts purposefulness as an essential characteristic of human activity and recognizes tendencies to <u>attribute</u> to other human beings an intentionality behind their actions (Malle, 1999, 2007). In clinical settings, tendencies to attribute intent to communications can lead to distrust of patients, particularly when there are no obvious pathophysiological sources of pain complaints (Craig, 2006). This is consistent with Burke's (1966) observation that humans typically explain the behavior of others using <u>motivational</u> language . Nonetheless, even reflexive/automatic behavior indicative of pain that manifests itself outside of conscious deliberation is subject to this analysis. .

A model of pain focusing upon communication requires an acceptable definition of "communication". Our approach is inclusive of actions that may or not be intentionally sent, as well as the intentional and unintentional reactions of receivers to the cues or signs. Communication occurs in dyads, or larger groups, when the actions of sending parties are predicated upon the audience and have an impact upon receiving parties. Typically communicative acts (e.g., use of speech), intended and consciously received, are accompanied by unintended actions. For example, language prosodics, facial expression and body language invariably accompany speech during pain communications, and have an impact on the observer's understanding of the sender's subjective state. Nonverbal, unintended actions can occur in the absence of a capacity to formulate intentional behavior. Health care professionals, family members, and others may or may not be responsive to actions signaling pain in people without the capacity for speech or other purposive actions that convey painful distress. Neonates are recognized as born with a capacity to effectively communicate painful distress through facial expression and cry (Grunau & Craig, 1987). Relatively stereotypic behavior significant of

painful distress can also be recognized in other populations with communication limitations (Hadjistavropoulos, Breau, & Craig, 2011a). Similarly, observers may or may not recognize the cues significant of painful distress in others.

Activities of senders and receivers can be discordant and need to be understood in a broad context. A receiver of a message (verbal or nonverbal) may have the capacity to accurately perceive the state of the sender, or misperceive by distorting, amplifying or minimizing the painful state of the sender. Communication of pain, then, is not a tennis match where the message (ball) is sent from one person (server) to another (defender) but is a far more complex activity. Like the game of tennis itself, which involves hidden and explicit rules, assumptions, and a broader social context of expectations and constraints, illness is embedded in social comprehension in a similar way ("Big boys don't cry", "natural birth is better than recourse to epidurals"). There are extensive social and cultural contexts for expressing pain ("Take it like a man", "Don't whine"), and explicit and familiar saws about the way in which pain should be faced ("Grin and bear it", "No pain, no gain"). All of these provide a communicative context that celebrates those who perform in a socially acceptable way and disparages those who act spontaneously but counter-normatively ("He died, as he lived, a total wimp, screaming, whining and complaining at every available opportunity, treating every pain as intolerable"). In short, pain happens and is expressed in a manner that confounds biological dispositions and social conventions. Receivers may be disposed to help, but they also may be indifferent, or disposed to exploit the pain of others, with the context of social symbols and expectations important to the receiver's reactions. That context of social expectations is a major part of understanding the way in which "communication" occurs between members of the same society or even species.

Pain Expressions within the Context of Evolution

Evolutionary models provide organizing principles for understanding the biological, psychological, and social features of the pain communication perspective. It is commonly understood that escape and avoidance of physically dangerous events enhances survival and reproduction. Tropisms can be observed in unicellular organisms, transforming into the biobehavioral systems serving pain that become increasingly complex across the phylogenetic scale. Avoidance of noxious stimulation can be reliably observed in crustaceans and fish (e.g., Barr, Laming, Dick, & Elwood, 2008; Sneddon, Braithwaite, & Gentle, 2003), signaling a capacity for conditioned fear and anticipatory behavior in settings associated with pain. More complex contextually predicated sociobehavioral reactions to pain can be observed in avians and mammals (Church, 1959; de Waal, 2008; Langford et al., 2006; Watanabe & Ono, 1986).

Efforts to understand the evolution of human pain must add and incorporate the capacities for complex, high-level cognitive, linguistic, and social functioning observable in humans (Craig, 2009; Craig et al., 2011). The capacity to modulate experience and expression of pain through reference to others appears superimposed upon the more ancient self-oriented system dedicated to survival and safety (Goubert, Craig, & Buysse, 2009a; Ickes & Decety, 2009). This is consistent with the description of the human species as a uniquely *symbol-using animal* (Burke, 1966), although interaction and communication are not restricted to the use of symbols.

Negative emotional states, including those involved in the subjective pain experience, facilitate pursuit of goals and guide actions according to the organism's priorities (Cosmides & Tooby, 1992) with physical welfare being paramount (Damasio, 1994). The genes which regulate this system are, like the majority of genes, those which convey advantage for survival and/or mating such that they are passed into successive generations: "We are walking archives of

ancestral wisdom" (Cronin, 1991). This not only describes emotion in the individual but is inclusive of dyadic sensitivities.

The most widespread response to another's distress signals occurs in parental care. In altricial species requiring prolonged parenting for offspring to survive, one can recognize in the neonate and young infant coordinated patterns of behavior that signal pain and other negative affective states to observant others along with parallel sensitivity to these states and typically, immediate urgent reactions by parents. Parental sensitivity to infant emotion may provide the evolutionary basis for sharing emotions of non-kin and responding to minimize distress, which enables group-level, goal-related activities which benefit all. This ranges from emotional contagion in birds, whereby all react in a coordinated manner when one gives an alarm signal, to the complex socially-sensitive empathic responses of some primates which reduce in-group conflict (de Waal, 2008).

These reactions depend on the capacity to share the experiences of conspecifics elicited via some signalling system (Plesker & Mayer, 2008). Access to sophisticated symbol systems is well-developed by humans, who utilize *language* as a symbol system. It is a form of expression but also as an instrumental mechanism to *do* things (Carl & Duck, 2004). Common pathways in the brain for processing direct and observed experiences of distress (Decety & Jackson, 2004; Jackson, Rainville, & Decety, 2006b) provide an understanding of the biological mechanisms engaged. The proposal that altruistic responding reduces not only the distress in the suffering person which evoked it but also empathic distress in the responding observer seems parsimonious, although the extent to which personal benefit drives altruistic behavior remains debated (Lamm, Nusbaum, Meltzoff, & Decety, 2007b). Some have argued that, for the genetic variants underpinning empathy to persist, it is necessary only that altruistic acts are mostly returned, however distally, without proximal motivation (Tooby & Cosmides, 1996).

The personal experience of pain demands attention, interrupts activities (Eccleston & Crombez, 1999), motivates escape and avoidance behavior, makes it aversive to use the injured part, and promotes recovery and healing through self-management (energy conservation and vigilance). Nevertheless, pain is rarely, if ever, exclusively private, as automatic/reflexive behavioral reactions as well as controlled/reflective actions have the capacity to communicate painful distress to others. Pain captures the attention of observers, as it signals a potential proximal threat to them individually or as a group (Yamada & Decety, 2009). Both group and individual benefits arise from effective communication of pain. Like the experience of pain, expression of pain is best construed as wholly or partly "hard-wired", emerging in the course of mammalian evolution and conserved in humans, although subject to socialization processes. The automatic/reflexive reactions can be construed as "communication as action".

Many uniquely human adaptations, such as our capacity to use language (the ultimate symbol system), appear superordinate to automatic/reflexive/expressive capabilities observed in both human and nonhuman species (e.g., nociceptive withdrawal reflexes that serve to avoid injury) (Hadjistavropoulos & Craig, 2002). As in nonhuman species (Mogil, 2009) immediate pain-related reflexive reactions are conspicuous in humans and allow for the study of nociceptive behavior even in newborns (Andrews & Fitzgerald, 2002; Grunau & Craig, 1987). The ability of a receiver to recognize and react to cues signaling potentially painful events in others, as evident in Pavlovian vicarious conditioning (Bandura & Rosenthal, 1966; Craig & Lowery, 1969), can lead to observational learning of fear and avoidance of potentially dangerous situations (Goubert, Vlaeyen, Crombez, & Craig, in press). Fear of pain is a well researched phenomenon in humans (Asmundson, Vlaeyen, & Crombez, 2004) leading to the fear avoidance model of pain (Vlaeyen & Linton, 2000). Moreover, recent evidence suggests that observing others in pain can lead to fearful apprehension related to previously neutral stimuli and that fear and attitudes about pain of

health care providers can affect their recommendations and, thus, the patient pain experience (Coudeyre et al., 2006; Houben, Gijsen, Peterson, de Jong, & Vlaeyen, 2005; Olsson & Phelps, 2007).

Although reflexive withdrawal and the ability to associate cues with risk of harm require minimal cognitive capabilities, human language, cognition, and communication have resulted in more complicated patterns of responding to pain and pain-related situations. Pain communications can be conceptualized as occurring both automatically and at levels requiring purposeful cognitive processing (Craig, 2009; Hadjistavropoulos & Craig, 2002). The self-report of pain requires conscious processing and can easily be distorted intentionally. Automatic behaviors represent stereotyped, reflexive patterns of response to impending tissue damage that are outside immediate conscious awareness or cognitive control. The automatic behavioral reactions reflecting sensory/affective processing observable with some continuity across mammalian species, including humans, are capable of instigating in observers automatic, physiological reaction patterns with or without higher conscious processing (e.g., Craig, 1968; Craig et al., 2010; Rinn, 1984). It is important to note, however, that automaticity can be over-ridden to some degree.   For example, the facial display of pain can be voluntarily controlled, although the upper face is less amenable to deliberate control (Rinn, 1984).   As a second example, an individual may temporarily inhibit the automatic response of dropping a very hot dish, coming out of the oven and causing a burn to the hand, in order to salvage one's dinner. The automatic/reflexive reactions, as well as engagement of the higher-level executive processing associated with memory, reasoning, meaning-making, and action are reasonably construed as "communication as interaction" with the receiver responding to and interpreting expression of the suffering person's status and needs. It is these higher levels of cognitive

processing that transform human pain expression (as "action") into a relatively unique form of social process (as "transaction").

Humans are motivated to understand events in terms of their causes and behavioral and contextual impacts (Kazdin, 2000). Since expressed pain is interpreted by others as a signal of danger associated with tissue damage, it is in this sense *communication as action.* Engagement of the receiver also can evoke *communication as interaction* and *communication as transaction*, particularly when common symbol systems are engaged. The interaction is observed at a basic level when humans and other mammals withdraw from physical danger. But again, at a relatively basic level, pain communication as transaction can be observed when a receiver delivers succor to a person in pain within the context of protection, for example, when a mother cares for a newborn experiencing pain. When higher levels of executive function are engaged, as when there are attempts to communicate symbolically, the complexities and potentials of human interactions and transactions are substantially compounded.

Pain may be one of the first conscious human experiences requiring problem solving. Emergence in the course of evolution of complex human cognitive and affective processing increased the range of possible adaptive responses when pain was experienced or anticipated. *Homo sapiens* benefited from symbol-using communication systems that allowed for more flexibility in response to the biological predispositions that control individual pain behavior and expression in other species. Moreover, such communication systems allow for greater participation in others' pain experiences and in social networks capable of understanding what is expressed. This represents a key to providing support and care to an individual in pain.

Pain Expression and Altruistic Behavior

There are many adaptive advantages in the ability to recognize pain in others (crucially this is *communication as interaction* or *communication as transaction* but **not** *communication as*

action). Evidence for prototypical facial expressions expressing pain as well as a range of

negative and positive emotions indicates selective pressures towards specificity of biologically

predisposed expressions (Craig et al., 2011). Although such expressions may have the

evolutionary advantage of alerting observers of impending danger, pain expressions often lead to

altruistic behavior. Precocial species are born capable of independent survival without

dependency on parents or others for protection, shelter and food. In contrast, humans, as an

altricial species, are fully dependent upon the care provided by others. Neonates are remarkably

fragile and vulnerable, requiring care for years following birth. Throughout this span of time,

parents and other caretakers must be sensitive to the children's needs, as this ensures specific

care and conserves resources. Hunger, fatigue, the impact of injury or disease, and other states,

require particular responses from others. Most often, the adult response must be specific to the

infant's state, yet that state is very often expressed in a *generalized* message of distress and

leaves the parent with the immediate problem of decoding the generalized message into a

specific one. There is evidence that children's cries are particularly salient and commanding of

parental attention and feelings of urgency (Murray, 1979), but the accumulated evidence is that

cries do not encode specific states such as pain; they mostly represent the severity of distress

experienced by the child (Craig, Glibert, & Lilley, 2000). All the same, most new parents

acquire extended experience with their infant in order to learn the source of each cry. As infants

mature and acquire experience, their cries come to resemble speech acts (Craig & Korol, 2008;

Craig, Stanford, Fairbairn, & Chambers, 2006). Much of the new parent's frustration at hearing

a newborn's distress is precisely at the failure of interactive communication: the message often

signals/expresses/enacts general distress without specifying the precise source, and the parent's

job is to rapidly receive, decode and create an accurate interpretation ("interaction") of what

specific stimulus is generating the general distress, whether hunger, physical discomfort, or some

sudden shock so that the correct response can be transacted. Fortunately, infant emotional experience often is manifest in behavior with patterns of facial display recognized as the most sensitive and specific to pain (Grunau & Craig, 1987).

Frustrations relating to efforts to accurately decode and interpret pain messages also occur within the context of the health care system where health professionals are often faced with patients who present with challenging non-specific pain symptoms ("actions") that are sometimes related to histopathological changes that cannot be seen in imaging due to device limitations (Giles & Crawford, 1997). In such a context, pain complaints can be misinterpreted, sometimes leading to accusations about malingering, resulting in frustration in both health professionals and patients.

Expression/social communication of pain (as action) does not invariably lead to sympathy for the person in pain ("interaction") and beneficent transaction, although deliberate cruelty and infliction of pain is, understandably, little studied. Altruistic behavior also has its limits. Persistent crying can lead to deterioration of the attachment bond between infants and parents, and increases the risk of physical abuse (Crouch, Skowronski, Milner, & Harris, 2008). Such risk for abuse may be even greater when the parent does not know how to decode the message. Limits on what seem to be biological imperatives to minimize children's pain and distress are evident in use of corporal punishment, infanticide, and willingness to disregard pain when it is incidental to procedures of known prophylactic, diagnostic, or treatment of value to the child. There also is evidence of pervasive under-estimation of pain in children that serves, perhaps, as the basis for systematic under-assessment and under-management of children's pain. The case is illustrated in parents' and nurses' estimates of their children's pain. When these are contrasted with children's self-reports, they are generally, but not invariably, different

(Chambers, Giesbrecht, Craig, Bennett, & Huntsman, 1999; Chambers, Reid, Craig, McGrath, & Finlay, 1999).

Similar examples relate to the care provided to other vulnerable populations where communication of painful distress is even more difficult or there is a tendency to ignore the needs of the individual (Hadjistavropoulos et al., 2011a; Prkachin, Solomon, & Ross, 2007). The argument can be generated for children and adults with cognitive impairments such as dementia and congenital intellectual disability. Non-responsiveness or negative responsiveness in a caregiver, previously interpreted solely as "neglect", can now be seen through our communicative model as a failure of communication: not a failure of the sender (communication as action), nor a failure of the receiver to receive the message (communication as interaction), but as a failure of the receiver to share and understand the symbols of the sender (communication as transaction).

The Role of Pain Expression in Social Roles and Relationships

Pain has important implications for social relationships. People in pain are likely to manifest illness behavior, assume sick roles, and lapse into the status of invalid. There is evidence of continuity with nonhuman animal species. In nonhuman primates, pain can lead to the seeking of comfort, reassurance from one another (de Waal, 1998) and dominance among rivals often is established when one inflicts, through violent aggression, injury, and pain upon another. As indicated earlier, among humans, emotional attachments between infants and their caregivers may be affected by prolonged and incorrectly interpreted distress in the child. Moreover, chronic abdominal pain related to school avoidance (Walker, 1999) can be associated with aversion to social demands in school and overprotective parenting. People suffering chronic pain usually find their interpersonal relationships deteriorating. The extent of such deterioration or lack thereof would, of course, be dependent on the social context and sometimes

on difficulties with accurate decoding and interpreting pain messages (Deyo & Phillips, 1996;

Paulson, Norberg, & Soderberg, 2003). Deterioration of interpersonal relationships may be

reflected in inability to participate in usual activities at home, work, or in recreational pursuits

and irritability associated with persistent pain (Kappesser & de C. Williams, 2008).

People with chronic pain conditions are often viewed with suspicion by health care and

insurance providers when suffering from medically unexplainable conditions (Craig, 2006; Tait

et al., 2009). The vast majority of people suffering from chronic pain do not have diagnoses

based on pathophysiological injuries or disease, and are at risk of being marginalized from

meaningful professional care and treatment (Cowley, Cowley, Norton, & Norton, 2009). Pain

cannot be observed directly; indeed the evidence is that the experience of pain is associated with

very complex serial and parallel activity in many brain and spinal systems, reducing the

likelihood a unique brain signature of pain will be forthcoming (Melzack & Wall, 1988). People

of all ages are capable of misrepresentation of pain. Children may suppress, exaggerate or fake

pain because of the perceived social consequences of doing so, for example, to avoid being

denied opportunities to play or to gain attention and sympathy from parents and other adults

(Larochette, Chambers, & Craig, 2006). Older adults often suppress pain complaints (Lyons,

Langille, & Duck, 2006), fearing pressures from family and others to pursue living arrangements

that could result in loss of independence. Many other illustrations could be generated

demonstrating the impact of painful conditions, and social modulation of the display, on how

others react to the person in pain. All of them involve recognition of either the success or failure

of symbolic encoding or decoding (symbolic interaction) or else too clear a recognition that the

surrounding symbolic social context will lead to other types of responses (e.g., ignoring a

decoded pain message).

It is important to note that the nature and quality of social support and human resources for the person in pain has an impact on pain, suffering, and related disability. Social support can enhance psychological well being for persons with chronic pain (Burckhardt, 1985; Faucett & Levine, 1991; Murphy, Creed, & Jayson, 1988; Turner & Noh, 1988) although when it is excessive to the point that it becomes solicitous it can lead persons with chronic pain to show more pain and disability (Boothby, Thorn, Overduin, & Ward, 2004; McCracken, 2005; Paulsen & Altmaier, 1995). Conflict and problems with social relationships can also increase somatic and psychological distress (Feuerstein, Sult, & Houle, 1985; Fiore, Becker, & Coppel, 1983; Goldberg, Kerns, & Rosenberg, 1993). Successes in symbolic interactions and rejection of symbolic sharing represent the difference between social acceptance and welfare, and social rejection and distress.

The Communications Model of Pain

The Communications Model of Pain (Craig, 2009; Hadjistavropoulos & Craig, 2002; Hadjistavropoulos, Craig, & Fuchs-Lacelle, 2004; Prkachin & Craig, 1995) is consistent with biopsychosocial conceptualizations. It recognizes that biological mechanisms are fundamental to the psychological processes engaged during pain experience and expression, but also directs attention to social processes as causes and consequences of pain experience and the manner in which pain is expressed. As well, the Communications Model explicitly incorporates attention to how those in the social environment play a determinative role in pain experience and expression through devoting attention to the process of decoding expressive pain behavior and responding to the person in pain.

The Communications Model is rooted in Rosenthal's (1982) formulation of processes whereby observers decode and react to psychological states encoded in the behavior of other persons. Previous use of the model focused on specific aspects of the experience such as the role

of facial expression in the communication of pain (Prkachin & Craig, 1995), the challenges of

delivering care to infants (Craig, Korol, & Pillai, 2002), differences between automatic/reflexive

and executive responding during painful events (Hadjistavropoulos & Craig, 2002), with the

current paper providing a far more comprehensive statement integrating clinical, neuroscience,

social-communications and evolutionary perspectives.

Consistent with Rosenthal's description (1982), the process of communication is seen as

a three step process (A→B→C). An internal experience (Step A) is encoded with varying

degrees of fidelity in expressive behavior (Step B). If observers are to respond with sensitivity,

the expressive behavior requires decoding (Step C). The resulting inferences will dictate the

nature of their response to the person. Reactions will vary in accuracy and may be neutral,

benevolent or malevolent. The model is shown in Figure 2. In our terms, communication as

action (the behavior of the sender and the reaction of the receiver) leads to communication as

interaction (the dyadic process) which may be embedded or understood in a broader social

context (including culture) as a feature of ongoing interpersonal transactions.

Communications Model Step A – The Internal Pain Experience

As illustrated in Figure 2, the experience of pain consists of cognitive, affective,

behavioral, and motivational components, has distinct brain correlates and is affected by (and

interpreted through) the contextual, cultural, interpersonal and situational context (depicted in the

figure as a gray background) in which it occurs (Melzack & Wall, 1965). Pain is a personal,

subjective experience that cannot be observed directly. In humans, it comprises an interplay of

sensations, images, feelings and thoughts. The complexities of this experience are evident in

imaging studies demonstrating both parallel and serial activation of numerous regions of the

brain during painful events (Casey & Bushnell, 2000).   The experiential, behavioral, and

biological parameters of the pain experience are well described (Chapman & Nakamura, 1999;

Hadjistavropoulos & Craig, 2004). Both experimental and anthropological studies have

demonstrated that cultural, interpersonal and social contextual influences (e.g., religious

ceremonies, socialization in familial and culture specific models) are potent determinants of the

experience of pain (Morris, 2010). As an example of an important experimental study

demonstrating the social contextual determinants of the pain experience we note the work of

Craig and Weiss (1971). This work was replicated by a succession of related studies

demonstrating the impact of tolerant and intolerant social models on various self-report and

behavioral indicators of pain (Craig, 1986). Specifically, Craig and Weiss (1971) studied

participants' response to experimentally induced pain. Some participants were exposed to an

experimental confederate modeling low pain tolerance and other participants to a confederate

modeling high pain tolerance. Exposure to an intolerant model, led to reports of greater pain.

Similarly, exposure to a tolerant model led to reported thresholds better than three times greater

than the thresholds reported by participants observing a model who was less tolerant. Chambers,

Craig and Bennett (2002) conducted a related laboratory study involving a cold pressor task

(i.e., keeping one's hand in very cold water) and showed that girls (ages 8-12 years), whose

mothers were taught to interact in a pain-promoting manner during exposure to the task, reported

more pain than daughters of mothers' in the control group. While the Craig and Weiss (1971)

and the Chambers et al. (2002) study are examples of experimental research that supports the

influence of social context in the pain experience (e.g., Craig & Weiss, 1975),expressions of pain

might have been influenced by demand characteristics of the experimental context (e.g., a

reluctance to report increased pain in the presence of a tolerant model) and may not have

accurately reflected the internal experience. Subsequent replications of the impact of social

models utilized measures of pain less vulnerable to social demand and impression management,

including nonverbal measures (Prkachin & Craig, 1985), psychophysical, and psychophysical

measures (Craig & Prkachin, 1978), supported the observation that social influences have an impact on the subjective experience of pain. Substantial work involving neuroimaging procedures (Coan, Schaefer, & Davidson, 2006) and reviewed in the next section, also supports the role of social/contextual factors in the experience of pain.

Instruments such as the McGill Pain Questionnaire (Melzack, 1975) tap the qualitative features of pain. Affective qualities of the pain experience are evident in both language and nonverbal pain expression (Hale & Hadjistavropoulos, 1997). The interplay between cognitive and affective features of the experience are evident in research demonstrating that fear of pain is exacerbated by catastrophizing (an exaggerated negative orientation to actual or anticipated pain, including elements of rumination, magnification, and feelings of helplessness) (Sullivan, Feuerstein, Gatchel, Linton, & Pransky, 2005; Sullivan et al., 2001; Vlaeyen & Linton, 2000). Catastrophizing has been associated, concurrently and prospectively, with a variety of pain-related outcomes including pain severity (Sullivan, Bishop, & Pivik, 1995), post-operative pain (Forsythe, Dunbar, Hennigar, Sullivan, & Gross, 2008), pain behavior (Sullivan, Adams, & Sullivan, 2004), analgesic consumption (Jacobsen & Butler, 1996), withdrawal from daily activities (Verbunt, Sieben, Vlaeyen, Portegijs, & Knottnerus, 2008), and occupational disability (Sullivan & Stanish, 2003). Pain catastrophizing has been identified as a risk factor for the development of persistent pain and a prognostic indicator of poor treatment outcome (Haythornthwaite, Clark, Pappagallo, & Raja, 2003; Linton, 2005; Picavet, Vlaeyen, & Schouten, 2002; Sullivan et al., 2005).

The subjective experience of pain, associated psychological distress, and related communications-interactions impact human relationships. For example, chronic pain severity is associated with greater psychological distress and relationship dissatisfaction in both partners (Ahern, Adams, & Follick, 1985; Bigatti & Cronan, 2002; Cano, Gillis, Heinz, Geisser, & Foran,

2004a; Cano, Weisberg, & Gallagher, 2000; Geisser, Cano, & Leonard, 2005; Nicassio & Radojevic, 1993; Rowat & Knafl, 1985; Walsh, Blanchard, Kremer, & Blanchard, 1999). Moreover, the presence of chronic pain is related to lower marital and sexual satisfaction in the person with pain as well as the spouse (Flor, Turk, & Scholz, 1987; Maruta, Osborne, Swanson, & Halling, 1981). Self-report and behavioral studies of social factors in pain experience are also supported by the burgeoning field of social neuroscience and experimental studies of social factors modulating pain in non-human animals (Langford et al., 2010a; Langford et al., 2006; Langford et al., 2011).

Brain mechanisms associated with the experience of pain. Advances in neuroscience leading to fuller understanding of brain mechanisms associated with pain have now led to recognition that neurophysiological regulation of pain includes responses to the social environment in which pain is experienced (Singer et al., 2006). Given references in the neuroscience literature to "social pain", (Dewall et al., 2010; Eisenberger, Jarcho, Lieberman, & Naliboff, 2006; Eisenberger, Lieberman, & Williams, 2003) it is important to note that our focus is on pain that is associated with tissue damage or is described in terms of such damage and not on "social pain". Specifically, the term "social pain" has been used to describe the psychological and brain correlates of social exclusion and related social interactions and is distinguished from "physical pain" (Dewall et al., 2010; Eisenberger et al., 2006; Eisenberger et al., 2003). Although "social pain" shares some of the neurophysiological basis with pain associated with tissue damage, the distinction between "social" and "physical" pain can be challenged because, as we have demonstrated, pain can never be purely physical nor purely psychological (Melzack & Wall, 1965). The psychological distress, that is common to both "social pain" and pain associated with tissue damage, may account for identified commonalities in neurophysiology.

A large body of research has accumulated documenting the activation of several brain structures (see Figure 2) in response to various nociceptive inputs (e.g., mechanical, thermal) applied to different tissues (e.g., cutaneous, visceral) in healthy individuals (Apkarian, Bushnell, Treede, & Zubieta, 2005). Although study of brain activity provides direct access to biological information, this still requires recognition and interpretation by those studying the responses.

The distributed brain networks reliably activated during painful procedures (see Figure 2) are consistent with the known anatomy and neurophysiology of a complex neural system that conveys nociceptive information from the spinal cord to the cerebral cortex through interacting ascending and descending pathways (Price, 2000; Rainville, 2002). In addition to the thalamus and the somatosensory cortex, a number of structures receive the nociceptive signals. Those include several subcortical nuclei, including part of the limbic system, the insular lobes and the anterior cingulate cortex, as well as the prefrontal areas (Dube et al., 2009; Price, 2000; Rainville, 2002; Staud, Craggs, Robinson, Perlstein, & Price, 2007). Descending pathways from these regions down to the periaquadctal gray area in the brain also contribute to the assessment and appraisal of the internal experience (Price, 2000; Rainville, 2002). Chronic pain conditions have been associated with abnormal activity or altered brain morphology within this brain network, consistent with the position that such conditions involve maladaptive plastic changes in pain processing brain systems (see Apkarian et al., 2005; Kupers & Kehlet, 2006). Although much remains to be clarified regarding the specific brain mechanisms associated with, and potentially underlying, various chronic pain conditions, the experimental data and the relatively limited clinical data has provided some significant advances in our understanding of pain neurobiology. Importantly, experimental pain research has not been limited to bottom-up approaches based on stimulus-evoked responses, and significant development has been made using the additional information provided by self-report. This research has contributed to the

modern view of the pain experience, which relies not only on somatosensory processes, but on cognitive and affective mechanisms as well. The ground work has been laid for understanding the impact of social phenomena on brain correlates of painful experience.

Furthermore, hypnosis interventions targeting the sensory or the affective dimension of pain were found to modulate the responses in different brain areas, namely the somatosensory and cingulate cortex, each associated more specifically with self-reports of pain intensity or pain unpleasantness, respectively (Hofbauer, Rainville, Duncan, & Bushnell, 2001; Rainville, Duncan, Price, Carrier, & Bushnell, 1997). Consistent with the general organization of the brain, the perception of pain relies on the activation of thalamo-cortical systems with multiple areas contributing differentially to various aspects of the experience. Research focusing on cognitive and emotional aspects of brain activation during pain quite convincingly advocates in favor of multidimensional assessments of pain in order to capture the complexity of the experience and of the underlying neural processes (Apkarian et al., 2005; Rainville, 2002).

It is also important to note that the context of a study may also influence the brain response to constant pain stimuli in the absence of significant effects on self-reports of pain intensity or unpleasantness. This contextual effect was suggested in a report on pain-related somatosensory activation in the hypnosis studies described above. In revisiting these data, Bushnell et al. (1999) found stronger somatosensory activation at baseline (i.e., prior to the modulatory intervention) in experiments focusing on the sensory aspects of pain. More recent results have confirmed this contextual effect by showing stronger responses in the somatosensory and adjacent posterior parietal cortex when the subjects' attention is directed to the spatial location of pain while stronger responses are found in the anterior cingulate cortex, the frontal pole, the insula and emotion-related brain subcortical nuclei (e.g., amygdala and hypothalamus) when the subject is instructed to focus on pain unpleasantness (Kulkarni et al., 2005). It is clear

that findings in these areas vary as a function of study methodology, including the instructions given to participants.

An example of an authoritative investigation examining the role of social contextual factors in the experience of pain involved the study of social support which has also been shown to have an effect on both pain reports and fMRI responses. In a study of women who were subjected to electric shock while holding their spouse's hand, the experimenter's hand or no hand at all, participants communicated reduced pain unpleasantness when holding their spouses hand (Coan et al., 2006). From an fMRI standpoint, results indicated a pervasive attenuation of activation in the neural systems supporting emotional and behavioral threat responses when the women held their husband's hand. Most interestingly, the effects of spousal hand-holding on neural threat responses varied as a function of marital quality, with higher marital quality predicting reduced threat related neural activation in several brain regions (e.g., right anterior insula, superior frontal gyrus). This type of research provides strong support for the conclusions of studies of social and contextual factors (e.g., Craig & Weiss, 1975) that did not involve study of brain responses. Nonetheless, it is important to note that neurophysiological approaches to understanding pain face the same major challenge as other available measurement methods in pain research; pain is a subjective experience and all pain measures provide only indirect accounts of the phenomenon. All available measures of pain (behavioral or physiological) exhibit, at best, some valid but inevitably imperfect relation to the pain experience.

The description of brain activity during human painful experience, whether the result of injury, disease, or the application of noxious stimuli, contributes to the understanding of the underlying neurobiological mechanisms. Most study of human brain processes during pain has been driven by experimental models of pain evoked by the application of acute noxious stimulation, with lesser attention to disease models.

Related animal models. Although there have been numerous investigations of the biological basis of pain in animals, of special interest to the Communications Model of Pain are studies demonstrating the importance of the social environment in the pain experience of non-human species. These studies complement related neurobiological investigations conducted with human participants. A small number of modern experiments have reported pain modulation by social interactions in laboratory rodents. For example, sibling male mice, reunited after a period of separation, show increased huddling and an opioid system-dependent increase in pain threshold (D'Amato & Pavone, 1996), as well as enhanced responsivity to morphine (D'Amato, 1998). Neuropathic pain behavior, using a denervation model, can be altered simply by cohousing with rats exhibiting differential levels of that behavior, or even with bedding from those rats (Raber & Devor, 2002). An analysis of a large archival data set of data in the tail-withdrawal test revealed a within-cage order-of-testing effect, such that later-tested mice were more sensitive to the noxious stimulus than earlier-tested mice. This effect was abolished if mice were not returned to their home cage after testing, implying the involvement of social communication (Chesler, Wilson, Lariviere, Rodriguez-Zas, & Mogil, 2002a; Chesler, Wilson, Lariviere, Rodriguez-Zas, & Mogil, 2002b). These findings support the continuity of social influences in the pain experience along the phylogenetic scale.

Communications Model Step B – Encoding of the Pain Experience in Expressive Behavior

Given the ultimately subjective nature of the pain experience (other than sympathetic or contagious distress), clinicians have traditionally relied on self-report and many have argued that it should be the "gold standard" in pain assessment (Engel, 1959; Melzack & Katz, 1999). A balanced approach necessitates recognition of the advantages and limitations of self-report and in particular the limitations of "self-report" as a communication mechanism (Schiavenato & Craig, 2010). Thus, the "gold standard" may be "fool's gold" if its limitations are not recognized. Self-

report is often interpreted as *communication as action*, a direct message, a truth statement about experience communicated without modification directly from its source. However, it is also readily demonstrated to be a form of *communication as transaction* (a statement designed to influence the observer and subsequently interpreted by the observer who brings a shared understanding of cultural normative patterns leading to addition of "overtones" to the original "message"). The self-report confounds components that reflect the nature of pain experience with the encoder's recognition of an impact of the expression on others. Prkachin and Craig (1995), borrowing from cognitive psychology, proposed that central motor programs are responsible for expressive aspects of the pain experience, whether these are verbal or non-verbal "communications as action". They examined in particular the motor program responsible for facial displays of pain, consistent with Paul Ekman's (1977) concept of an "affect program". Other related but at least partially independent programs would be responsible for verbal report and other forms of non-verbal behavior (Keefe & Lefebvre, 1994).

In examining differences between self-report and nonverbal expression of pain, Hadjistavropoulos and Craig (2002) made a major distinction between reflexive automaticity in response to pain and reactions that require cognitive executive mediation, They argued that some behaviors, such as the verbal report of pain, are primarily reliant on higher mental processes (represented by the larger side of the verbal expression solid in Figure 2), whereas certain non-verbal reactions (e.g., nociceptive withdrawal reflexes and some facial expression) typically reflect expressive automaticity (represented by the larger side of the non-verbal expression solid in Figure 2).

It is recognized that automaticity can be overridden to some extent, particularly when brain systems support the capacity to engage in complex cognitive, linguistic, and social behavior. Examples include suppression of nociceptive reflexes (Campbell et al., 2008; France,

France, Absi, Ring, & McIntyre, 2002), demonstrations that facial expressions of pain can be overridden to some degree by conscious effort (Hill & Craig, 2002; Rinn, 1984), and expected social consequences - that is to say, the anticipated response of others to the display - can influence pain displays themselves (e.g., Fordyce, 1976; Larochette et al., 2006).   An example of an important illustration demonstrating that automatic, reflexive responses can be overridden to some degree is the study by Hill and Craig (2002). These investigators videotaped low back pain patients' facial expressions in response to a painful physical therapy procedure with the instruction to not attempt to manipulate naturally occurring facial expressions of pain or to pretend that the procedure did not hurt. Patients were also videotaped during rest (neutral facial expression). Facial expressions were analyzed using the Facial Action Coding System (Ekman & Friesen, 1978) and the genuine and suppressed expressions were compared. These investigators found that intentionally masked facial expressions of pain resulted in a minimization of the pain display with only subtle differences between the masked and the neutral expression (e.g., there was a greater frequency of mouth opening and residual brow lowering during the masked facial expressions). It is important to note, however, that suppression of reflexive facial expressions may be more difficult to achieve at higher pain intensities.

Culture-specific shared understandings (represented as the large gray background oval in Figure 2) serve to affect the expression and its interpretation. Naïve interpretations of self-report as the "gold standard", construing self-report as corresponding (i.e., isomorphic) to the experience of pain, reflect a widely shared misinterpretation of the nature of self-report. However, observers, that is to say interpreters of expressed "messages", tend to be generally aware of the potential for response biases, at least on the self-report of pain, and express preference for non-verbal behavior over verbal behavior when judging/interpreting the credibility of pain displays (Poole & Craig, 1992). Displays/expressions of pain can be inhibited when

expression is likely to lead to adverse consequences (Melzack & Wall, 1988), suggesting that an individual's experience of pain does not necessarily translate precisely into an expressive message, but that it will be first filtered through the sender's appreciation of the manner in which the expression may be interpreted. For instance, an individual may inhibit the reflexive drop of a hot platter if this would lead to the loss of a difficult-to-prepare dinner, or to loss of face as an individual unable to tolerate pain (communication as transaction).

It is useful to characterize the actions of persons in pain as either protective or communicative (Sullivan, 2008). Protective behaviors (e.g., withdrawal reflexes, guarded postures, disabled behavior) can serve as communicative actions if responders are sensitive to these actions. They exist in the first instance to meet the needs of the person to escape or avoid pain, but they can also be meaningful to sensitive observers. Here the actions are expressive, that is, capable of communication, but their prime role does not appear to be social in the first instance. Certain patterns of behavior can also be protective by communicating distress to others, thereby engaging the care of motivated observers. The prototypical illustration of this type would be the impact that facial expression and other behavioral manifestations of pain have on mothers' caring for infants. In this instance, the reflexive nature of pain expression and reactions to it can be observed. Emerging empirical research has supported the distinction between protective and communicative pain behaviors. Variations in physical demands of a task, for example, have been shown to impact the display of protective pain behaviors but not the display of communicative pain behaviors (Sullivan et al., 2006). Nonetheless, it is recognized that such functional distinctiveness of the two types of behaviors is restricted to their primary function and not their social function (Williams, 2002; Zeskind, Sale, Maio, Huntington, & Weiseman, 1985). That is, although guarding is considered a protective behavior, it also communicates distress (Sullivan, 2008).

The most specific automatic, nonverbal pain communication in humans is facial expression (Williams, 2002). Its role in the communication of pain in infants, including neonates, indicates it is "hard-wired", but it later becomes modifiable through socialization and social context, like other facial expressions of emotion (Ekman, 1993). Facial expressions of pain consist of coordinated biologically predisposed reaction patterns that are distinct from other emotional expressions (such as fear, anger, and disgust) (Simon, Craig, Gosselin, Belin, & Rainville, 2007) and only partly under voluntary control (Craig, Hyde, & Patrick, 1991). For instance, Craig et al. (1991) asked patients to suppress or exaggerate the facial display of pain in response to a discomforting physical therapy procedure. Consistent with the study of Hill and Craig (2002) discussed earlier, based on analysis using the Facial Action Coding System (Ekman & Friesen, 1978) it was determined that instructions to suppress facial displays of pain, made nonverbal pain expressions more difficult to identify but did not eliminate them entirely.

The facial display of pain has been shown to be reliable and consistent across the lifespan from preterm infants to older persons with cognitive impairment, consistent across painful stimuli (Prkachin, 1992); and a major influence on observer judgments of behavior as indicative of pain (Williams, 2002). Nevertheless all these hardwired and constricted emotional expressions (communication as action) are socially unleashed as soon as they become communication as interaction or communication transactions and may be interpreted in different ways in different social contexts (Duck & McMahan, 2009, 2010). Although several other behaviors are consistently associated with pain, guarding in particular (Keefe & Block, 1982), none appears unique to pain. Nevertheless, they merit study, bearing in mind the functions of pain described above.

Systematic study of the impact of the social context (depicted in Figure 2 as a large gray oval shape within which pain and its communication occur) on verbal and nonverbal displays of pain

has received little attention relative to the study of biologically based interventions (Hadjistavropoulos et al., 2004). Nevertheless, there is substantial evidence of the impact of socialization on pain display. Verbal report slowly comes to reflect familial/cultural linguistic demands as children mature and acquire the social and language skills necessary to effectively interact with others (Craig et al., 2006; Stanford et al., 2005). Effectively communicating painful distress with caregivers, professional and otherwise, is a complex social task. It is reasonable to assume children learn and respond according to "display rules" operating within and outside consciousness (Larochette et al., 2006). Similarly, children have ample opportunity to observe patterns of pain response in others, with this influencing both self report (Craig & Weiss, 1971; Goodman & McGrath, 2003) and nonverbal emotional expression of pain (Olsson & Phelps, 2007; Prkachin & Craig, 1987) demonstrating that others in the life experience of the individual and the immediate social environment serve as powerful social models for how one should react when anticipating or experiencing pain and attempting to bring it under control (Craig, 1986; Hermann, 2007).

Other social factors, including social normative patterns and display rules, have demonstrable effects on pain expression (Gnepp & Hess, 1986). For example, in a critically important study, Kleck et al. (1976) studied the effects of observation by another on response to painful stimulation. More specifically, responses to pain responses (i.e., both self-report and facial behavior as assessed by judges who viewed videos of the participants' responses) to electric shock were attenuated when subjects were being observed. Self-report tends to be exquisitely sensitive to the social context as perceived, with individuals typically using language to optimize situational outcomes and nonverbal expression is demonstrably sensitive to context in both adults and children (Crombez & Eccleston, 2002; Hadjistavropoulos & Craig, 2002; Kleck et al., 1976; Larochette et al., 2006; Prkachin & Craig, 1985; Sullivan et al., 2004; Vervoort et al., 2008b;

Williams, 2002; Zeman & Garber, 1996). Levine and De Simone (1991) showed that males

report less experimentally-induced pain in the presence of an attractively dressed female

experimenter than in the presence of a male. Moreover, a dental procedure conducted in a clinic

led to greater reports of pain than the same procedure conducted in the experimental laboratory

(Dworkin & Chen, 1982). People can be reasonably successful in suppressing or exaggerating

nonverbal pain expression (Crombez & Eccleston, 2002; Hadjistavropoulos, Craig,

Hadjistavropoulos, & Poole, 1996a; Hill & Craig, 2002; Larochette et al., 2006; Vervoort et al.,

2008b), in accordance with perception of situational demands. As indicated earlier, like other

negative facial expressions, expression of pain tends to be inhibited in the presence of strangers,

although this inhibition may be lifted when strangers are recognized as (professional) caregivers,

potentially able to relieve pain (Williams, 2002). This evidence contrasts with the popular

formulation that patients 'exaggerate' pain-related behavior in the presence of actual or potential

caregivers. Recognizing the importance of contextual, relationship and social convention factors

necessitates conceptualizing communication as action, as communication as interaction or

communication as transaction.

The potential for augmentation or suppression of pain displays is important to the Sullivan et

al. (2001) Communal Coping Model of Pain Catastrophizing. It was proposed that the

expressive pain displays and pain-related disability of high catastrophizers serve a

communicative function. The model draws on theoretical perspectives addressing the

interpersonal dimensions of coping (Coyne & Fiske, 1992; Lackner & Gurtman, 2004; Lyons,

Sullivan, Ritvo, & Coyne, 1995; Taylor et al., 2000). According to the Communal Coping

Model, pain expressions of high catastrophizers serve to maximize the probability that distress

will be managed within a social/interpersonal context (Sullivan, Tripp, & Santor, 2000). This

suggests optimistic expectations of those expressing pain (communication as action) that this

communication will correctly be interpreted by observers and that this will lead to the correct

decoding of communication (i.e., communication as transaction). Sullivan et al. (2001) proposed

that high catastrophizers would engage in exaggerated pain expression in order to maximize

proximity, or to solicit assistance or empathic responses from others. High catastrophizers'

expressive pain displays might also be used to induce others to alter their expectations, reduce

performance demands, or as a means of managing interpersonal conflict.

Numerous investigations have yielded findings relevant to interpersonal predictions of the

Communal Coping Model of pain catastrophizing. Research has shown that the relation between

catastrophizing and self-reported pain severity is greater when pain patients are living with a

spouse or caregiver than living alone (Giardino, Jensen, Turner, Ehde, & Cardenas, 2003).

Catastrophizing has been associated with an insecure attachment style (Ciechanowski, Sullivan,

Jensen, Romano, & Summers, 2003; McWilliams & Asmundson, 2007) and with higher levels of

short-term spousal support (Cano, 2004). Catastrophizing has also been associated with negative

interpersonal outcomes where the emotional demands of high catastrophizers seem to tax the

support resources of significant others (Boothby et al., 2004; Keefe et al., 2003; Lackner &

Gurtman, 2004).

Although there are some inconsistencies in the literature (e.g., Kunz, Chatelle,

Lautenbacher, & Rainville, 2008a) researchers have identified associations between

catastrophizing and a propensity to display pain behavior (i.e., communication as action) in both

adults (Sullivan, 2008) and children (Vervoort, Goubert, & Crombez, 2009a; Vervoort et al.,

2009b; Vervoort et al., 2008b). Sex differences in pain behavior have been shown to be mediated

by catastrophizing, even when controlling for pain intensity (Keefe et al., 2000; Sullivan et al.,

2000). Research has shown that catastrophizers display more prolonged pain behavior in the

presence of others than when alone (Sullivan et al., 2004). Catastrophizers' expressive displays

of pain lead observers to infer more intense (but not more accurate) pain experience (Goubert et al., 2009b; Sullivan, Martel, Tripp, Savard, & Crombez, 2006). Observers with high levels of catastrophizing also infer more intense pain in others (Sullivan et al., 2006a). In children, catastrophizing has been shown to be associated with greater expression of communicative but not protective pain behaviors (Vervoort et al., 2008a). In adults with chronic pain conditions, catastrophizing has been associated with greater expression of both communicative and protective pain behaviors (Thibault, Loisel, Durand, Catchlove, & Sullivan, 2008). While many research findings on the relation between catastrophizing and expression of pain behavior are consistent with the predictions of the Communal Coping Model, a critical element of the model that has yet to be tested is whether the pain behavior of high catastrophizers is driven by 'communication intent'. Another issue that has to be considered in relation to the Communal Coping Model is the extent to which expression is dependent on the nature of the observer. There is also a need to clarify the factors that have led to inconsistencies in findings concerning the relation between catastrophising and pain expressiveness (e.g., Kunz et al., 2008a). Moreover, Vlaeyen et al. (2009) tested the Communal Coping Model prediction that high catastrophizers show more pain expression in the presence of observers regardless of the threat value of the pain but their data did not support this hypothesis as the researchers found that the effect of threat on pain expression was dependent on social context and independent of the effects of catastrophizing,

Although the coping style of high catastrophizers might appear maladaptive, it is important to consider that a communal coping style might only become truly maladaptive under chronic pain or chronic illness conditions. In response to acute pain, exaggerated pain displays may result in a precarious, but sustainable, balance between satisfying support or affiliative needs, and increasing distress. Under acute pain conditions, overall benefits may outweigh costs,

and reinforcement contingencies (e.g., increased support, attention, empathic responses) may actually serve to maintain the expressive style of high catastrophizers. When conditions become chronic, this balance may be disrupted such that costs begin to outweigh benefits. Others' responses may become increasingly negative when distress displays extend over time (Cano, 2004). The disrupted balance may find expression as leading to increased interpersonal conflict, social rejection and depression (Keefe et al., 2003). These issues are examined in more detail in the pain decoding section below. Overall, it is clear that the communication of pain is affected by social, cultural and intrapersonal determinants.

Brain correlates of pain expression. Emphasis in the Communications Model on the relevance of the dimension of automaticity versus cognitive executive mediation of pain expression is supported by research demonstrating that brain correlates differ for automatic pain behaviors and self-report. Acute noxious stimuli activate several brain areas but this activation does not necessarily correspond directly to self-reports of pain (Bornhovd et al., 2002; Buchel et al., 2002). More interestingly, brain responses to stimuli of constant intensity vary proportionally to the self-reported pain across subjects (Coghill, McHaffie, & Yen, 2003) and in various conditions where pain is modulated intra-individually (see Apkarian et al., 2005). These studies have provided convincing evidence that brain responses to painful stimuli are largely determined by individual differences and shaped by the psychosocial context. Changes in the magnitude of brain responses to acute noxious stimuli were found to correlate with changes in self-reports of pain produced by manipulations involving attention/distraction (Bushnell et al., 1999), expectation (Koyama, McHaffie, Laurienti, & Coghill, 2005), hypnosis (Hofbauer et al., 2001; Rainville et al., 1997), and emotion (see review in Apkarian et al., 2005). As an example of this important research, Koyama et al. (2005) investigated healthy volunteers who underwent thermal pain stimulation. Time intervals differing in length and a tone were used to manipulate

expectations regarding stimulus intensity. The association of the intervals with stimulus intensities were established during a training session prior to the fMRI scanning. The participants provided self-reports of both expected and perceived pain intensity. The researchers concluded that expectations of decreased pain affected both the subjective pain report and corresponding pain-brain activation.

In discussing the significant but nevertheless limited correlation between pain ratings (i.e., communication as action) and brain responses to acute noxious stimuli, one must also consider the inherent limitations of self-report measures. Aside from the issue of credibility associated with voluntary or involuntary response biases, one must recognize that self-report depends on complex higher-order cognitive function (including self-censoring). These processes involve magnitude-estimation and accurate cross-modality matching to a pain scale or a verbal format. Recent work suggests that pain-related brain responses may partly reflect non-specific magnitude-estimation processes inherent to pain perception and to pain evaluation (Baliki, Geha, & Apkarian, 2009) (note however that this factor is adequately controlled in studies involving magnitude-estimation of non-painful as well as painful stimuli). In most pain studies, self-report further implies retrospective ratings of the pain felt, thereby involving additional memory processes. Experimental psychophysical results suggest that memory traces of pain sensory information may not be as accurate as we usually assume although reliability may be relatively good (Rainville, Doucet, Fortin, & Duncan, 2004). Registering and maintaining pain-related information in memory also relies on some, but not necessarily all, pain-activated brain areas (Albanese, Duerden, Rainville, & Duncan, 2007; Kong et al., 2006). This implies that the pattern of brain response to acute pain in many studies may partly reflect memory processes in addition to the experience of pain. Overall, although the evaluative and memory processes may be controlled for by contrasting brain responses obtained in similar rating conditions involving

non-painful sensation, some steps of these complex processes may have some modulatory effect on the processing of sensory and affective information (e.g., attention bias towards the experiential dimension reported). Each processing stage underlying the encoding of the experience in the proper communication format may further produce some interference affecting the accuracy of the self-report measure.

The brain correlates of self-reported pain can be contrasted with what is known about the corresponding correlates of non-verbal pain behavior. Although there is abundant literature demonstrating the important complementary information provided by automatic non-verbal responses to pain, very little is known about the brain mechanisms underlying such responses. This is likely explained, in part, by the very strong clinical and research emphasis on self-report measures. Facial expression can be measured in functional magnetic resonance experiments. Indeed, a simple video camera compatible with the magnetic environment allows filming the face of participants during scanning of the brain while painful stimuli are being delivered. This technique has recently been applied to study the regulation of the facial expression of pain produced by contact heat stimuli adjusted individually to produce strong pain based on self-reports (Kunz, Chen, Vachon-Presseau, Lautenbacher, & Rainville, 2009). These preliminary results showed that brain activation patterns reflected both interindividual differences and trial-by-trial fluctuations in the strength of pain expressive displays assessed quantitatively using the facial action coding system (FACS-Ekman & Friesen, 1978; i.e., after accounting for differences in pain sensitivity assessed using self-report). Importantly, brain responses were positively associated with pain expression in parts of the pain matrix, within areas known to receive ascending nociceptive signals from the spinal cord through the thalamus. This is highly consistent with the position that nonverbal pain expression reflects part of the brain response to noxious stimuli not fully captured by self-report measures. Moreover, painful trials with no facial

responses and individuals displaying few pain expressions had stronger activation of some

prefrontal areas potentially involved in the down-regulation of pain-related responses in other

brain areas and/or in the suppression of behavioral pain responses. This suggests that

communication as action is mediated by prefrontal systems regulating the automatic encoding

processes. In fact, these systems and most notably the medial aspect of the prefrontal cortex are

recognized as representing a key region for the integration of contextual and cultural factors in

the regulation of social behaviors (Damasio, 2003).

Research has also focused on the responses of patients with brain disorders. Specifically,

Kunz and colleagues demonstrated that although patients with dementia may be relatively

comparable to healthy controls on self-report measures of pain (when available) produced by

acute noxious stimulation, these patients also display increased motor reflexes and facial

expression and reduced autonomic responses (Kunz, Mylius, Scharmann, Schepelman, &

Lautenbacher, 2009; Kunz et al., 2007). These differences may reflect changes in pain-related

neural processes not adequately conveyed by verbal self-report. These include an increase in pain

sensory processes, abnormal pain regulation, and/or disinhibition of some pain responses.

Recent brain imaging research with patients with Alzheimer disease has provided evidence that

brain responses to acute painful stimuli are indeed increased in target pain-related pathways

including sensory and affective areas, consistent with the notion of enhanced pain processing and

possibly related to impaired self-regulation (Cole et al., 2006). The investigation of brain

correlates of pain expression in persons with cognitive impairments may provide further insight

into the physiological status of these patients and contribute to the external-validation of the

corresponding behavioral measures in these populations.

Animal models. There are surprisingly few studies of spontaneous pain behaviors in

domesticated or wild animals, limiting their use in the study of interpersonal and communication

processes in non-human species. Mogil and Crager (2004) criticized the preference for measuring evoked pain behaviors in laboratory animals (see also Mogil, 2009). An obvious difficulty is identifying responses unique to pain, but using reversal by analgesics or anesthetics has demonstrated probable pain behaviors even in crustaceans (Barr et al., 2008) and fish (Sneddon et al., 2003). After the immediate phase of escape and avoidance, pain behaviors largely involve withdrawal from usual activity, energy conservation, and an apathetic demeanor, reported in fish, birds, possibly reptiles and amphibians, and mammals. In mammals, pain may be indicated by reduced appetite, grooming, socializing, and vocalization. It is now clear that mice make a clear grimace after the application of many (but not all) noxious stimuli. A *Mouse Grimace Scale* has been developed, based directly on human facial pain scales (see Williams, 2002), which displays high reliability and accuracy, and appears to be useful for the quantification of tonic pain (Langford et al., 2010a). Whether mice can recognize or react to facial expressions of pain in their conspecifics is the subject of current experimentation. Chronic pain is far less evident from behavior, and withdrawal and energy conservation appear commoner than restlessness and agitation.

Behavioral signs of pain (i.e., communication as action) in social animals may indicate vulnerability, both to predators and to social rivals among conspecifics. The latter has been suggested as the basis for the tendency for primates, otherwise facially expressive, to mask pain expression in an attempt not to lose social status (Plesker & Mayer, 2008). This is a strong anthropomorphic attribution, but it ultimately relates to the recognition that communication has an enriched meaning within the particular social context.

Mice provide a potentially useful animal model of social dimensions of pain as they can be affected by each other's pain. A series of experiments was designed to systematically examine the impact of social communication on pain behavior and expression in mice, by

varying the social context of the pain testing (Langford et al., 2006). Demonstrating the

importance of social context, mice tested in dyads were found to display higher levels of pain

behavior, compared to isolation testing, if tested in the presence of a similarly affected

conspecific, but only if that conspecific was a familiar (i.e., co-housed for at least 14-21 days).

Bidirectional modulation was observed, in that observation of a lower level of pain behavior in a

cage-mate decreased the observer's own pain behavior. In addition to changes in overall pain

behavior levels, a statistically significant synchronization of the behaviors themselves were

observed, even at a distance (Langford et al., 2006). These effects were interpreted as akin to

emotional contagion, a rudimentary form of empathy (Preston & de Waal, 2002). Moreover, the

modulation of pain by social context is apparently influenced by dominance/submission

relationships among mice in a dyad, as analgesia was observed in submissive mice tested for

pain in the company of dominants (Gioiosa, Chiarotti, Alleva, & Laviola, 2009).

Decoding the Pain Message – Step C

Figure 2 illustrates that the decoding of pain expressions is affected by the clarity of the

sufferer's message (with verbal messages, generally easier to interpret than non-verbal ones) and

that decoding occurs within the context of contextual, cultural, situational and

interpersonal/social factors all of which have been demonstrated to affect interpretation of pain

signals (e.g., Martel, Thibault, Roy, Catchlove, & Sullivan, 2008). Observer characteristics, such

as age and gender, have also been shown to affect observers' decoding of pain

(Hadjistavropoulos, LaChapelle, Hale, & MacLeod, 2000a; Hadjistavropoulos, McMurtry, &

Craig, 1996b; MacLeod, LaChapelle, Hadjistavropoulos, & Pfeifer, 2001). In addition, as the

large double headed arrow in Figure 2 illustrates, the actions of the observer could then lead to

the removal or reduction of the pain stimulus but could also affect the pain experience itself. For

example, it has been demonstrated that perceived social support has a positive impact on the

sufferer's pain experience (Lopez-Martinez, Esteve-Zarazaga, & Ramirez-Maestre, 2008).

The attention of those observing pain expressions (communication as interaction) is

drawn to the possible presence of a physical threat to the self, potentially conferring survival

advantage. Within social groups, an empathic response (communication as transaction) may

elicit help, and evolutionary models of empathy and altruism are well developed (de Waal,

2008). Less attention has been devoted to the potential for malevolent reactions, but the

incidence of interpersonal harm and violence implies benevolent reactions to the distress of

others represent only one possible reaction. Help-giving has costs, so it is conditional on (judged)

genuineness or fairness of the claim for help, and we are alert to possible 'cheating' (i.e., the

possibility that an individual is aiming to derive a benefit without truly satisfying the

requirements for the provision of that benefit) (Cosmides & Tooby, 1992). In relation to pain,

this would suggest that the observer's response will be influenced by his or her relationship with

the person in pain, by his or her judgments of fairness or deservingness or the person in pain, and

by perception of threat to him or herself. Observers' pain estimates are affected by the intensity

of the pain expression observed, the manner in which it is expressed (Craig et al., 2011), by their

own empathic tendencies (Saarela et al., 2007), as well as by information with a bearing on

deservingness: for medical personnel, evidence of damage or conversely of possible deception

(Kappesser, Williams, & Prkachin, 2006; Tait et al., 2009) and, for family members, evidence of

fairness (Kappesser & de C. Williams, 2008). Ultimately, however, pain messages

(communication as action) must be successfully decoded by observers (communication as

interaction) if they are to be considered of value (communication as transaction). It is important

to note, however, that successful decoding usually implies a less than perfect understanding of

the sufferer's experience considering the subjectivity of pain (Ickes & Decety, 2009), and often

is best understood as "good enough" for the actions of senders and receivers to achieve common

goals (Goubert et al., 2009a). This occurs because the pain experience is far more personal than

exteroceptive perceptual processes such as those involved in vision and audition because the

latter are directed toward publically available objects whereas pain is directed toward internal

perceptions of bodily damage that are not directly observable (Auvray, Myin, & Spence, 2010).

Several authors have argued that characteristics of the observer and contextual variations

are also important in decoding (Decety & Jackson, 2004; Goubert et al., 2009a; Goubert et al.,

2005; Williams, 2002). These different influences are clearly described within a model of

empathy and pain (Goubert et al., 2005; Goubert et al., 2009b). Within this model, which is

consistent with the Communications Model of Pain, empathy is defined as a sense of knowing

the experience of another person, and includes cognitive (e.g., estimation of the nature and

severity of others' pain), affective (e.g., self-interested distress or other-directed sympathy), and

behavioral components (e.g., helping, in all its varieties). These reactions are influenced by four

types of determinants: (1) characteristics of the person in pain and the availability of the cues that

signal pain (these are the bottom-up determinants, such as the specifics of the pain behavior

observed); (2) characteristics of the observer (these top-down determinants include higher-level

decision making that reflecting personal learning experiences and potential biases); (3)

contextual characteristics, including the physical setting (e.g., the presence of blood, wounds, or

danger in the setting) and the social context (e.g., who is present and cultural expectations about

the meaning and symbols for expressing and responding to pain); and (4) the nature of the

relationship between observer and observed (e.g., professional, family, stranger). These

determinants may interact in determining the observers' empathic interpretations as well as their

behavioral responses.

Understanding the impact of observation of others' pain upon observers requires appreciation of the distinction between what is observable and how it is processed by others, and this distinction maps onto our communication model. Goubert et al. (2005) note that receiver reactions represent an amalgam of two processes, those that are "bottom-up" or initiated by the input from senders, and those that are "top-down", representing contributions by the receiver in the form of meaning imposed on the input as a result of memory, reasoning, judgment, etc. Three different, yet related, elements can be distinguished in the impact of pain expression upon observing others: First, the *detection and discrimination* of available (pain) information, which implies *attentional* processes to pain in the other (Goubert et al., 2009a). Second, the *meaning* attached to what has been observed (e.g., the estimation of the others' pain). Third, the *emotional* and *behavioral responses* of the observer (Prkachin & Craig, 1995; Prkachin et al., 2007).

The role of personal characteristics of observers has received research attention. In line with the cognitive-affective model of pain in which the interruptive function of pain is central (Eccleston & Crombez, 1999), individuals who personally engage in high levels of catastrophizing have been found to (1) be more attentive to the pain signals/cues of others (Sullivan et al., 2006a; Van Damme, Crombez, & Lorenz, 2007); (2) estimate the pain of others to be more severe and/or interpret others' experiences more negatively (Goubert et al., 2009b; Pincus & Morley, 2001); and (3) experience more personal distress (Goubert, Vervoort, Sullivan, Verhoeven, & Crombez, 2008). As an example of an important investigation demonstrating the role of observer characteristics in decoding the pain message (and more specifically the role of observers' tendency to catastrophize), observers of videotaped back pain patients (engaging in a lifting activity) completed a measure of catastrophising prior to completing any observations (Martel et al., 2008). Results demonstrated that high catastrophizers estimated more pain in

others than low catastrophizers. This catastrophizing reaction pattern would be expected to affect how they would engage in delivery of care that might be aimed at reducing, avoiding or escaping the other's pain (Batson, 1991). Although high levels of alarm and urgent reactions in observers might be adaptive in the short term, preliminary evidence suggests that these responses have long-term maladaptive consequences for the person in pain: catastrophizing thoughts in caregivers, such as spouses or parents, are associated with higher levels of functional disability, pain intensity and emotional distress in the person suffering pain (Cano et al., 2004a; Goubert et al., 2006).

These studies of catastrophizing combine features of the detection (*attention* to another's pain), observer inference/interpretation, and observer emotional and behavioral reaction/responses to pain in others. In contrast to the reactions of those who engage in high levels of catastrophizing, the broad tendency in the population at large would appear to be less sensitive to the pain of others.

Numerous studies have identified widespread tendencies to fail to assess and to underestimate the pain of others (Chambers, Reid, Craig, McGrath, & Finley, 1998; Eritz & Hadjistavropoulos, 2011; Goubert et al., 2009a; Kappesser et al., 2006; Prkachin et al., 2007). Prkachin and Rocha (2010) demonstrated that pre-exposure to pain expressions (through repeated presentation of videos of individuals showing strong pain) diminished the likelihood of observers judging others to be in pain. Detecting, estimating and interpreting the pain of others has important implications for optimal clinical decision making, delivery of everyday care for pain, whether in clinical or non-professional settings (Chambers et al., 2002; Prkachin et al., 2007).

Hadjistavropoulos and Craig (2002) emphasized that the nature of expressive behavior also plays an important role in observers' ability to decode it. Craig et al. (2011) observed that

automatic (reflexive, unintentional) and controlled (intentional, purposive) manifest behavior are

reciprocated by similar automatic (unintentional, reflexive) and controlled (intentional,

reflective) reactions in observers. Both automatic and controlled behaviors can provide specific

information about pain (self-report can be valid; nociceptive reflexes and other automatic

behavior can be specific). Behaviors that are heavily reliant on cognitive mediations, such as

self-report, can be ambiguous as to their origins (Hadjistavropoulos & Craig, 2002). In patients

with severe cognitive impairments, who cannot provide valid self-reports of pain, signs of pain

could easily be confused with signs of non-pain-related distress (Hadjistavropoulos, Voyer,

Sharpe, Verreault, & Aubin, 2008).

The sufferer's characteristics also influence pain judgments as illustrated by the impact of

stereotypes on judgments of pain in others in a series of analogue studies involving videotaped

patients (Hadjistavropoulos et al., 2000a; Hadjistavropoulos et al., 1996b) and photographed

patients (Hadjistavropoulos, Ross, & von Baeyer, 1990) expressing pain. Hadjistavropoulos,

Ross, and von Bayer (1990) demonstrated that physicians tended to attribute lower levels of pain

to physically attractive patients (possibly because patient physical attractiveness was associated

with perceptions of better health) than physically unattractive patients. Similarly,

Hadjistavropoulos, McMurtry and Craig (1996b) found that physically attractive and male

patients were perceived as experiencing less pain intensity and disability than physically

unattractive and female patients even after controlling for frequency and intensity of expressive

behaviors. Physically attractive individuals were also viewed as less likely to catastrophize and

less likely to receive compensation than were unattractive patients. These impressions were

unrelated to actual physical functioning. In an investigation of age-related impressions,

Hadjistavropoulos, LaChapelle, Hale and MacLeod (2000a), investigated perceptions of patients

who differed in age and level of physical attractiveness. These patients were undergoing a

painful medical procedure (actual levels of patient pain expressiveness were experimentally controlled). Observers judging patient pain expressions on video perceived older and less physically attractive patients to be of lower overall functioning. An obvious limitation of these three studies is their analogue nature. More research in naturalistic contexts is needed to support the results of this research.

Patient coping styles have also been shown to interfere with observers' ability to make accurate judgments about pain and disability. In one study, undergraduate students were asked to make judgments about pain patients claiming disability compensation. The patients were described in fictitious vignettes that highlighted different approaches to coping with pain. Although patients' self-reported level of pain was kept constant across all vignettes, claimants who were described as catastrophizing or coping with pain largely by hoping for divine intervention were more likely to be perceived as disabled and as deserving compensation (MacLeod et al., 2001). Von Baeyer, Johnson and Macmillan, (1984) showed that more vigorous complaints led to more sympathetic reactions and higher ratings of patients' pain, distress and observer concern. Finally, Chibnall and Tait (1999) did not find any evidence that ethnicity (Caucasian vs. African- American) affected symptom evaluations by employees of a university health center. On the whole, however, the literature suggests that involvement of stereotypes and another psychological factors in judgment is more complicated than it may appear on the surface (Hadjistavropoulos et al., 2004; Tait et al., 2009). Pain judgements made about people with specific physical characteristics (bottom-up factor) can be affected by cultural and stereotypical thinking from the observer. This conclusion could be strengthened through more research conducted in naturalistic settings which could support the findings from the analogue laboratory investigations that we have reviewed here.

Additional research has indicated that others' responses to high catastrophizers may vary substantially; catastrophizing appears to elicit positive responses such as the provision of instrumental support (Keefe et al., 2003; MacLeod et al., 2001) at least initially, as well as negative responses such as criticizing the sufferer in pain or responding punitively (Boothby et al., 2004; Keefe et al., 2003). A persistent demanding style of high catastrophizing is likely to, over time, become a source of strain, burden, frustration and distress for caregivers (Cano, 2004). Although it is unclear how caregiver responses may impact upon pain catastrophizing, it is likely that both solicitous responses and negative responses may contribute to the persistence of pain catastrophizing (Guite, Rose, McCue, Sherry, & Sherker, 2007; Sullivan et al., 2001). Solicitous responses may positively reinforce catastrophizing. Negative responses may add to the aversive experience of pain, and further increase catastrophizer's vulnerability in dealing with pain (Claar, Simons, & Logan, 2008; McCracken, 2005).

Pain communication and interaction have received quite a bit of attention in the research on couples coping with pain. Much of this research has examined partners' responses to pain communication (Romano, Jensen, Turner, Good, & Hops, 2000; Romano, Turner, Friedman, & Bulcroft, 1991; Romano et al., 1992; Romano et al., 1995). Spouses often make errors when estimating the pain and disability of persons with pain (Cano, Johansen, & Franz, 2005; Cano, Johansen, & Geisser, 2004b; Clipp & George, 1992; Miaskowski, Zimmer, Barrett, Dibble, & Wallhagen, 1997). The assumption in the pain field has been that each spouse shares the same symbol system, which may not always be the case as in a husband who values visual symbols of pain and a wife who primarily uses verbal symbols. Following empathy models (Goubert et al., 2005), people with pain communicate their distress to their partners, who in turn have the opportunity to try to understand the significance of the message. Work in the close relationships literature provides further guidance for understanding the communicative process in couples

facing pain. Specifically, applying intimacy process models of interaction (Fruzzetti & Iverson, 2004; Laurenceau, Barrett, & Pietromonaco, 1998; Reis & Shaver, 1988) to pain suggests that expressing previously unshared thoughts or feelings about pain represents emotional self-disclosures. These self-disclosures could remain communication as action if the message were misinterpreted. Ideally, self-disclosures are communication as interaction because both partners will understand the significance and meaning of the message. In turn, spouses who use the same symbol system will understand the need for closeness and comfort and will respond with emotional validation, which may build intimacy or closeness in the couple, thereby transforming this interaction into communication as transaction. In contrast, spousal invalidation would reduce feelings of intimacy and disrupt emotion regulation (Fruzzetti & Iverson, 2004, 2006), perhaps because this response does not result in a healthy form of communication as transaction. This intimacy process approach is quite different from the operant perspective, which considers reassurance and emotional validation as typical reinforcers of pain behavior. While operant perspectives hold explanatory value, a conceptualization based on intimacy processes broadens the view of pain-related interaction by explicitly evaluating the emotional valence and quality of spouse responses in strengthening (or weakening) relational processes.

Careful study of pain-related interactions assists in understanding the impact of observer attention and interpretive meanings for pain behavior contingent responses and may assist in understanding both solicitous and nonsolicitous observer reactions. For instance, one study demonstrated that solicitous spouse responses can be delivered with hostility (Newton-John & Williams, 2006). Furthermore, a recent study demonstrated that emotional validation is qualitatively distinct from solicitous or overly helpful spouse behavioral responses, with the latter commonly interpreted in pain research as functioning to reinforce pain behavior. The factor-analytic study showed that spousal validation loaded negatively and invalidation loaded

positively with punishing spouse responses, which consist of responses laden with negative whereas solicitous and distracting spouse responses loaded on a separate factor (Cano et al., 2008). Note that couples with pain may engage in a variety of emotionally laden interaction behaviors aside from pain (Johansen & Cano, 2007). Although, for example, one study demonstrated that at longer pain durations, greater helplessness about pain related to lower spousal support (Cano, 2004), it is not known how helplessness was communicated to the spouses or how spouses responded to these disclosures. In summary, despite the adaptive value of effective pain communication decoding is a very complex process with multiple determinants, some of which have been identified here.

Decoding and neurophysiological reactions to pain in others (basic mechanisms).
Assuming that a robust non-verbal pain signal has been sent, reception of this signal by others can be examined through study of the neurophysiological reactions of observers. A growing number of neuroscience laboratories have used a variety of brain imaging techniques to examine biological correlates of pain communication from the observer's point of view. Observation of pain in other people is sufficient to activate a good part of the pain matrix, even in the absence of witnessing nociceptive stimulation delivered to the person in pain. As discussed previously, seeing another individual in pain has the potential to lead to at least two emotional responses: a supportive prosocial response and personal distress (Goubert et al., 2009c). Feelings of distress may be other-oriented, as in the case of sympathetic distress, or associated with self-interest, a consequence of interpreting the information about pain in others as a warning signal of potential danger or harm to the observer (Yamada & Decety, 2009). This may automatically activate the aversive response system related to pain and promote avoidance behaviors away from the other (Lamm, Batson, & Decety, 2007a). The second prosocial emotional response is an orientation toward the other person, and the urge to provide help or show compassion. While many

cognitive neuroscience studies in this field have championed the term "pain empathy", thereby

biasing the focus towards the second type of adaptive response, few have attempted to tease apart

these two facets of the response to the pain in others. Thus, the underlying cerebral mechanisms

uncovered so far could be related to various combinations of these two responses."

Figure 2 illustrates some of the brain regions shown to become activated in response to

observing another's pain. The first published report of an functional Magnetic Resonance

Imaging (fMRI) experiment comparing actual pain and the perception of pain in others showed

that part of the anterior cingulated cortex (ACC), the anterior insula, cerebellum and brainstem

were activated both when participants experienced a painful stimulus, as well as when they

observed a signal indicating that their partner was receiving a similar stimulus (Singer et al.,

2004). Subsequent studies with fMRI have confirmed that parts of the pain matrix associated

with the affective component of pain (mainly ACC and anterior insula) were activated by the

observation of bodily pain (Jackson, Meltzoff, & Decety, 2005; Morrison, Lloyd, di Pellegrino,

& Robets, 2004), the observation of facial expressions of pain (Botvinick et al., 2005; Saarela et

al., 2007; Simon, Craig, Miltner, & Rainville, 2006), and even when hearing pain-related words

(Osaka, Osaka, Morishita, Kondo, & Fukuyama, 2004). These initial studies, however, failed to

show consistent changes within the regions known to be associated with the sensory component

of pain, notably the somatosensory cortices. This raised the question of the extent to which the

observer resonates (i.e., activates the same cerebral systems as the model in pain) with the other.

In other words, to what extent do the two *share* a similar representation of pain? In one study,

where the level of this sharing mechanism was successfully manipulated, participants were asked

to assess the degree of pain in scenes depicting body limbs in painful situations (Jackson, Brunet,

Meltzoff, & Decety, 2006a). In one condition, participants rated how much pain they would

have in the situation (*Self*); in another condition, they rated how much pain another person would

have (a specific person present but not known to the research participant; *Other*). The results

revealed that both the *Self* and the *Other* cognitive perspectives were associated with activations

in the brain regions involved in the affective aspect of pain processing. Moreover, taking the Self

perspective, which behaviorally yielded higher pain ratings than taking the perspective of the

Other (even though the stimuli were exactly the same), involved the pain matrix more

extensively, and was associated with activation of the secondary somatosensory cortex and the

posterior part of the subcallosal cingulate cortex. Finally, distinct subregions within the insular

cortex were activated for the two perspectives. These results showed that the instruction was

sufficient to modulate the cerebral response and further suggested that the differing perspectives

taken yielded different levels of *matching*, which, in the case of the *Self* perspective, also

included somatosensory system (S2, insula proper). Subsequently, a meta-analysis of brain

imaging studies on pain observation was conducted showing that cerebral activity in the ACC

and insula was distributed in different subregions based not principally on whether nociceptive

stimulation was actually administered or not, but rather based on how "close" (i.e., the

experiential proximity and the tangibility, which can be modulated by numerous variables such

as the visual perspective, the quality of the visual stimuli, the relationship with the target in pain)

to the actual pain experience the experimental design was taking the participants (Jackson et al.,

2006b).

Subsequent neuroimaging techniques and designs, more focused on sensory-motor

functions, such as transcranial magnetic stimulation (Avenanti, Bueti, Galati, & Aglioti, 2005;

Avenanti, Minio-Paluello, Bufalari, & Aglioti, 2006), magnetoencephalography (Cheng, Yang,

Lin, Lee, & Decety, 2008), and electroencephalography (Bufalari, Aprile, Avenanti, Di Russo, &

Aglioti, 2007; Fan & Han, 2008; Jackson et al., 2007) demonstrated more consistently sensory-

motor changes in relation with the mental representation of pain through pain observation.

Using fMRI, one study even showed, much like the investigation using nociceptive stimulations described above (Kulkarni et al., 2005), that it is possible to tap into different sub-systems of the pain matrix (those subserving the sensory or the affective dimension) by varying instructions from "How much does it hurt?'' (i.e., sensory aspect) to ''How unpleasant is it?'' (i.e., affective aspect), during a pain observation task (Lamm et al., 2007b). As predicted, the findings showed more activity in contralateral primary sensory cortex when the focus was on the sensory dimension compared to when it was on the affective one. Again, this demonstrates that the brain response to cues signalling pain in others is highly dependent on the target of one's attention to different aspects of the experience during the observation and assessment of pain in others. This effect of the observer's perspective (which could differ depending on who the observer is) will likely result in the priming of different emotional, cognitive and behavioral output systems, thereby promoting different reactions towards the person in pain.

The perspective taken by the observer and the corresponding brain response is likely to be strongly influenced by individual differences and to vary considerably with the context. Some data is accumulating suggesting that the brain response can be influenced by the gender of the observer (Han, Fan, & Mao, 2008; Yang, Decety, Lee, Chen, & Cheng, 2009), the gender of the target (Simon et al., 2006), the interaction between the cultural background of the observer and the target (Xu, Zuo, Wang, & Han, 2009), the degree of realism of the stimuli (photographs vs cartoon drawings; Gu & Han, 2007), and personality traits (Avenanti, Minio-Paluello, Bufalari, & Aglioti, 2009). Amongst these factors, the contribution of memory has surprisingly been largely neglected. One exception is the study by Cheng and colleagues (2007) who demonstrated that the brain response of acupuncturists who believed acupuncture not to be painful was different than that of naïve participants to this practice. While the latter group showed the expected pain-related response including activation in the anterior insula, somatosensory cortices

and ACC, the former group did not. Moreover, the physicians showed additional activations in

the medial and superior prefrontal cortices, as well as the temporoparietal junction, two regions

known to be associated with emotion regulation and mentalizing processes (i.e., the ability to

make inferences about mental states such as emotions, desires and beliefs) (Frith & Frith, 2006).

This suggests that, with experience and perhaps with disbelief or substantial discounting of

others' pain, clinicians might be suppressing part of the spontaneous response to the pain of

others (perhaps the more automatic response related to the signal of potential danger). Note that

changes in brain activity in these regulation-related regions were also reported in an fMRI study

that compared a condition in which participants were told that the limb of the other person they

were looking at had been anaesthetized with another condition using the same visual scenarios

without the pain control manipulation (Lamm et al., 2007b). In another study, the medial

prefrontal cortex also was significantly more activated in conditions where pain had to be

attributed to body limb when participants were told that they were humans limbs as opposed to

artificial limbs (Jackson et al., 2006a). Thus, the level of experience as well as specific

knowledge about a situation can modulate the level of activity measured in the pain matrix and

also involve additional regulating systems.

Some research has examined the interaction between pain

experienced/expressed/reported and pain observed. Most of the preceding data have been

interpreted in the context of the Perception-Action Model (Preston & de Waal, 2002) and a

recent neurocognitive model of empathy (Decety & Jackson, 2004), which predict that very

similar cerebral systems are used during a behavior (be it an action, a sensation or even an

emotion) and the observation of the same behavior in another individual. Related to this work, an

electroencephalography study using laser-evoked potentials supports the idea that one's response

to the pain of others is influenced by one's own state. Valeriani et al. (2008) showed that

observing pain in others increased activity associated with the sensory component of the pain matrix. Further, they found that this somatic modulation of the signal was more important in individuals who rated the pain intensity as higher in themselves compared to what they attributed to others. These findings were interpreted as a demonstration that the pain-related empathic attitude towards another can be biased by the perception of one's own condition.

Future research avenues will need to focus beyond the initial observation of pain (which is only reflected by a pain rating in most brain imaging experiments) and start measuring subsequent behavior (of both the observer and the pain sufferer) in order to fully encompass the whole pain communication spectrum. More specifically, it would be useful for future studies to aim to tease apart the two facets(i.e., aversive and prosocial) of the response to the pain in others (by studying the response of the observer toward the person in pain) and determine whether some brain regions are more involved in one than the other. We can postulate that more automatic responses are linked principally to sensory and limbic regions, while the cognitively more complex response rely more on multimodal associative regions such as the medial prefrontal cortex and the temporoparietal junction.

Animal models. In examining evidence of relevance to the Communications Model from studies involving animal species, we consider evidence regarding the question of whether the perception of pain in another changes their social interaction. More simply stated: do mice approach or avoid other mice in pain? Studies suggesting that rodents are attentive to and affected by the distress of a conspecific date back 50 years, when Church (1959) demonstrated that rats can be conditioned using the footshock of another rat as the unconditioned stimulus (also see Chen, Panksepp, & Lahvis, 2009). Soon after it was demonstrated that rats would perform operant responses to terminate the distress of a conspecific (Rice & Gainer, 1962), although this was dismissed as arousal rather than altruism (Lavery & Foley, 1963). A recent

series of experiments was performed using a "jail" paradigm, in which some mice in a dyadic or triadic interaction were free to move and others were constrained behind metal bars (Langford et al., 2010b). Female, but not male, mice approached a familiar same-sex conspecific in pain more frequently than an unaffected familiar or stranger, but affected, conspecific. Most intriguing was the observation of an inverse correlation between social contact and pain behavior in cagemate but not stranger dyads, suggesting that proximity of a familiar and unaffected conspecific may have analgesic properties. This may be a newly discovered form of social buffering (Kikusui, Winslow, & Mori, 2006) and parallels related findings involving human research participants (Coan et al., 2006).

Developmental Considerations in the Communications Model of Pain

Although the basic elements of the Communications Model of Pain remain relatively constant as the model is applied across the lifespan, specific elements of the pain experience and expression can vary as function of developmental stage. Considering the internal pain experience, for instance, the capacity for nociception becomes evident early in life, with preterm and full term neonates displaying clear signs of painful distress (Craig, Whitfield, Grunau, Linton, & Hadjistavropoulos, 1993; Grunau & Craig, 1987; Hadjistavropoulos, Craig, Grunau, & Johnston, 1994; Stevens, Johnston, & Horton, 1994). This is accompanied by activation of spinal and supraspinal neurons in patterns and anatomic regions traditionally associated with the processing of painful stimuli (Anand & Craig, 1996; Dickenson & Rahman, 1999). Behavioral pain reactions, like facial reactions and vocalizations have adaptive value as they communicate distress and trigger appropriate care from parents or other caregivers and display considerable stability across the life span (Craig, 1998).

The ability to engage in self-control of painful expressions involves the simultaneous process of the ability to recognize that others have intentionality and use the same

communication systems as oneself, whether this be nonverbal expression of pain or the more complex symbolic use of language (Mead, 1934; Mills & Rubin, 1993). The inherited biological dispositions to display painful distress become transformed as infants initially acquire family-specific symbolic tools to interact with their parents, then steadily over the course of childhood acquire a greater ability for independent assessment of their and other people's experiences, which they come to describe and explain using the same symbolic and linguistic terms common to other members of the social community. From this systematic expansion of their symbolic flexibility springs the ability to engage in self or social control (and also to recognize their occurrence in others, Shotter, 1984).

In older persons, experimental studies have shown a small but somewhat inconsistent, increase in pain threshold with advancing age (i.e. a reduced sensitivity to faint pain) (Gibson, 2003; Hadjistavropoulos, Gibson, & Fine, 2011b). Clinical case reviews suggest that pain becomes a less-frequent presenting symptom in a variety of visceral and somatic medical complaints such as intestinal obstruction, post-operative pain, peritonitis, pneumonia, heart attack, angina, osteoarthritis and cancer (Pickering, 2005). Nonetheless, it is possible that older persons show a reduced willingness to admit having pain. There is also evidence of an age-related impairment in the structure and function of peripheral and central nervous system pain pathways (Gibson, 2003). Such changes could compromise the early warning functions of pain, could delay treatment and increase the probability of further injury or disease.

Somewhat paradoxically, older people are *more* vulnerable to strong or severe pain. Endogenous analgesic systems may be less efficient in older adults (Gibson & Farrell, 2004) and the ability to tolerate pain is reduced (Gibson, 2003). Moreover, it is more difficult to reverse the pathophysiological changes in the nociceptive system once they have occurred, as shown by a persistence of central sensitization (Farrell & Gibson, 2007). Such findings may be taken to

indicate a reduced plasticity in the aged nervous system and highlight a greater vulnerability to severe or persistent pain (Hadjistavropoulos et al., 2011b).

There are disparate findings concerning the impact of dementia on the pain experience (Cole et al., 2006; Hadjistavropoulos et al., 2011b; Hadjistavropoulos et al., 2000b; Kunz, Mylius, Schepelmann, & Lautenbacher, 2008b; Kunz et al., 2007). There is some evidence of increased pain expression (facial activity) in patients with dementia (Hadjistavropoulos et al., 2000b; Kunz et al., 2007). However, at present, it appears that dementia may impair pain perception at least in more severe cases, but the extent of change in pain perception with the progression of dementia is unclear (Hadjistavropoulos et al., 2011).

Similar to developmentally dependent pain experiences, pain expression can also vary with developmental status (Anand & Craig, 1996). Infants tend to communicate pain with cry, facial expression, and other non-verbal behavioral expressions, and the repertoire of means of pain communication increases with age. Studies indicate that children, from an early age, come to modulate their expression of pain and distress (Buss & Kiel, 2004), and they do so for a variety of reasons. The intensity of the pain contributes to pain expression, yet, the expression of pain is not solely a function of pain intensity. Indeed, pain intensity only explains a small-to-moderate amount of the variance in pain expression (Labus, Keefe, & Jensen, 2003; Vervoort et al., 2009a). Ability to modulate pain in the face of contextual and interpersonal circumstances would be the outcome of an interaction between ontogenetic maturation and the impact of life experience, including socialization in conventions utilized in the person's family and culture. Children are also aware of the interpersonal ramifications of expressing their pain and base their decisions to express, hide or even dissemble their pain on the type of social response they expect to receive following a pain disclosure. For example, children as young as nine years old report being less likely to express pain in front of a peer than in presence of their parent because they

perceive peers to be less accepting of pain displays and responding more negatively than parents (Zeman & Garber, 1996). Children may also hide their pain because of other-protective reasons (Crombez & Eccleston, 2002) like not wanting to worry or upset their parents (Larochette et al., 2006). Moreover, as with adults, cognitive factors and beliefs such as catastrophising (Vervoort et al., 2009a) are related to children's pain expressions.

With respect to pain expression in older adults, research is more limited than it is with children. Nonetheless, there is evidence that following the middle-adult years, seniors have a tendency to underreport pain complaints (Gibson & Chambers, 2004; Yong, Gibson, Horne, & Helme, 2001). Aging is also correlated with an increased prevalence of conditions, including Alzheimer's disease and other dementias, that interfere with effective pain communication (Hadjistavropoulos et al., 2011a) . As cognitive functions decline as a result of dementia, ability to self-report and describe pain deteriorates thereby increasing the need for observers to rely on the more automatic non-verbal forms of pain expression that are more likely to be preserved as the disease progresses (e.g., Hadjistavropoulos et al., 2007). Although research demonstrates that older persons with cognitive impairments may be somewhat more non-verbally expressive than similarly-aged cognitively intact peers, there are more commonalities than differences in such non-verbal expressions (Hadjistavropoulos et al., 2011a; Hadjistavropoulos et al., 2000b; Kunz et al., 2008b; Kunz et al., 2007). One hypothesis worth exploring is that the deterioration of the frontal lobes, notably the prefrontal cortex, with age and disease, could be at the root of the increased non-verbal expressions. Inversely, the prefrontal cortex, which is a key area for the production of socially adapted behaviour, notably through inhibition mechanisms, is known to develop during childhood up to early adulthood, and could explain the increased ability to modulate facial expression early in life. Investigations of the clinical utility of non-verbal pain assessment in seniors with severe dementia suggest that non-verbal expressions of pain can be

systematically observed and can guide treatment (Fuchs-Lacelle, Hadjistavropoulos, & Lix, 2008).

Finally, decoding of pain expressions is also developmentally dependent and this would be important to consider when applying Communications Model of Pain across the lifespan. More specifically, both the clarity of the pain message and ability to decode it are developmentally dependent. Infants display early sensitivity to non-verbal emotional cues and ability to understand verbal messages increases with early development. Observer bias that could potentially affect decoding of messages could also be affected by the age of the observer and the person in pain. For example, Hadjistavropoulos, LaChapelle, Hale and MacLeod (2000a) showed that older patients are perceived as experiencing more pain than younger patients even after control for the degree of pain that was expressed. Moreover, dementing illnesses that increase in prevalence with age could undoubtedly interfere with decoding ability.

Is the Communications Model of Pain Empirically Supported?

The Communications Model of Pain presented herein represents a synthesis of a very large body of empirical findings and, as such, is primarily based on an established knowledge base. This knowledge base was presented in an integrative and novel way relating the findings from diverse areas of the literature (e.g., neuroscience, social psychology, clinical psychology, communications theory) to the process of pain communication. A multitude of studies has been cited to support specific aspects of the model and the described interrelationships. Oftentimes, supporting studies have been of an analogue nature involving observations in the lab with university students acting as observers or other healthy participants subjected to experimentally induced pain (Craig & Weiss, 1975; Hadjistavropoulos et al., 1990; Hadjistavropoulos et al., 2000a; Hadjistavropoulos et al., 1996b; Martel et al., 2008). While the results of these studies are quite consistent with the Communications Model of Pain and their conclusions are enriched by

correlational (see Hadjistavropoulos & Craig, 2004), anthropological cross-cultural (Kosambi, 1967) and some animal research (Langford et al., 2006), further studies of the three stages (internal experience, encoding and decoding) of the Communications Model of Pain in naturalistic and medical settings are needed to strengthen the conclusions drawn by the analogue investigations.

Although, due to the complexity of human pain communication, it may not be feasible to test the model within a single study, many aspects of the model are testable and, generally, already well supported by a substantial body of existing empirical evidence. Nonetheless, the model serves as a useful template for future research particularly in areas where there is no adequate specificity in the processes involved. For example, more research could clarify the elements that are necessary for the quick and easy decoding of a non-verbal pain expression and the point in which a non-verbal pain expression becomes more difficult to decode because specific expression elements are missing. Similarly, more research could be conducted to clarify further the cultural determinants of pain communication.

In discussing pain communication, we made extensive reference to evolutionary viewpoints. Although these viewpoints are not directly testable, we were able to describe animal research that supports the position that social influences in the pain experience show some continuity across species which is consistent with evolutionary accounts. In the following section, we discuss more specific directions for future research.

Conclusions and Directions for Future Research

This paper represents the most comprehensive description of a Communications Model of Pain and the first formulation of the model that comprehensively incorporates basic brain mechanisms as well as an evaluation of the model from a communications perspective. The model serves as a synthesis of pre-existing findings and facilitates conceptualization of a vast

literature. As such, it has implications for both researchers and clinicians. From a clinical standpoint, for example, considering non-verbal pain behavior as being mostly reliant on reflexive automaticity has implications for selection of pain assessment tools among individuals with dementias and other conditions affecting intellectual function. As cognitive functions deteriorate, the primary focus of the assessment increasingly shifts away from self-report assessment tools and more into tools that tap more automatic modes of pain expression. Moreover, better recognition of social and psychological parameters affecting the pain experience and its communication can have broad ranging implications for clinical assessment and treatment. Currently, most health professionals receive minimal training on the psychosocial factors that affect the manner in which pain is communicated in clinical contexts. The Communications Model of Pain provides a framework for the training of health professionals with respect to such important issues.

Although the foundations of this model represent an integration of the pre-existing literature, our model provides a framework for future investigations. We described the complexity of the determinants of pain communications, the importance of expressive modality and, in particular, emphasized the dimension of expressive automaticity vs. cognitive executive mediation. As an example, one relevant model-driven question would be whether all non-verbal pain messages (which tend to rely largely on reflexive automaticity) are more difficult to decode than verbal reports and which types of non-verbal pain messages are the most difficult or easiest to decode.

Although there is a plethora of evidence in support of the social-contextual elements of the Communications Model of Pain, much of this research is analogue in nature and/or involves healthy volunteers. More research in naturalistic settings with pain sufferers could be conducted to support the findings of the analogue studies. Accounts of the differential functionality of pain

behaviors are preliminary and definitely need further investigation. Specifically, why and how people show pain, and how others perceive and respond to the sufferer's varying pain displays need to be investigated more thoroughly (de C Williams & Craig, 2006). Addressing the first question requires taking into account various kinds of pain expression as well as an assessment of varying determinants or antecedents. In addition to understanding how and why people show pain, understanding the nature of the interaction between the sufferer's diverse pain behaviors and those able to provide care is essential. Specifically, judgments and decisions of others determine whether and which interventions will be made available. Accordingly, we need to better understand how observers, from the broad range of cues arising from witnessing another person in pain, make judgments and decide upon care to be delivered (Goubert et al., 2009a) and, whether these interventions, in turn, are carefully tailored to the specific needs of the individual in pain. Hence, it is important to address not only what the various types of pain expression *mean* to the sufferer in pain but also what the various types of pain expression *communicate* to others. Although the prominence of the facial display of pain as a source of pain information among the various channels of non-verbal pain communication is well established (Kappesser et al., 2006; Sullivan et al., 2006), all behaviors may, to a varying extent, cue pain to others. In addition, the perception of pain is more than an estimate of others' pain *intensity*. In fact, perceiving others in pain may entail a complex cognitive and emotional appreciation of the pain-related thoughts, feelings, needs and motives of the sufferer in pain (e.g., appreciation of the sufferer's capability of dealing with pain or need for help).

The bulk of the cognitive neuroscience literature on pain communication has focused on the decoding phase of the communication process (e.g., Jackson et al., 2005; Simon et al., 2006). A number of studies now confirm that the sight of pain (be it from bodily pain, facial expressions, in adults, children or other populations) modulates the level of activity within the

pain matrix (e.g., Jackson et al., 2005). This initial response precedes the cerebral response related to the decision process that follows. Response to pain likely taps on additional brain regions, notably the medial prefrontal cortex involved in mentalizing. Studies focusing on observers' decision making processes will enhance our understanding of the prosocial response, or absence thereof, towards the person in pain. Nonetheless, developments in social neuroscience research are providing support for the notion of a pain representation rooted in a so-called pain-matrix and shared between the encoder and the decoder. However, much remains to be done to better understand the psychosocial variables affecting the brain mechanisms involved in decoding and the brain determinants of the decoder's response to pain communication.

Early brain imaging studies of pain have focused almost exclusively on the brain correlates of the internal pain experience by demonstrating how brain responses are modulated by psychological and contextual factors. However, this research has relied almost largely on self-report with only recent studies beginning to examine other, more automatic, encoding modalities such as facial expression (Kunz et al., 2009). Moreover, neuroimaging studies focusing on the communication of painful distress by pain patients are needed to supplement the pain neuroimaging work focused on experimentally induced pain.

In terms of animal models, although it is now clear that rodent behavior can be altered by the pain-related distress of their conspecifics, that rodents can attend to pain in another and will not necessarily avoid the stimulus, and that these affects are dependent on familiarity, it remains unclear whether or not true two-way communication is occurring. Future experiments might attempt to determine whether non-verbal pain signals (e.g., facial grimacing) of one mouse produce time-locked responses by another, and especially whether any evidence could be obtained suggesting that the mouse in pain changed its emission of those signals once the

original communication had been received. It should be noted as well that there is at least some

evidence that chronic pain is associated with ultrasonic vocalizations in mice (Kurejova et al.,

2010), raising the tantalizing possibility of pain-related vocal communication in rodents.

The Communications Model of Pain does not replace but supplements broader

biopsychosocial models by emphasizing the complexities of human pain communication. These

complexities of pain behavior, both from the sufferer's, as well as from the observer's point of

view, need to be addressed in order to come to a more comprehensive understanding of pain as a

social phenomenon. Although further research is needed, we hope that the detailed synthesis of

relevant knowledge into the Communications Model of Pain provides a solid framework for both

training in biopsychosocial influences affecting the pain experience and for organising and

guiding future empirical research.

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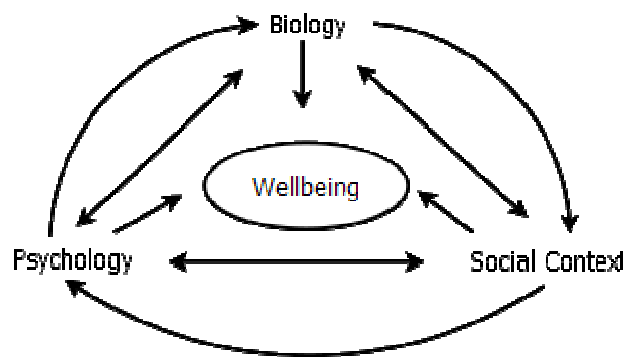
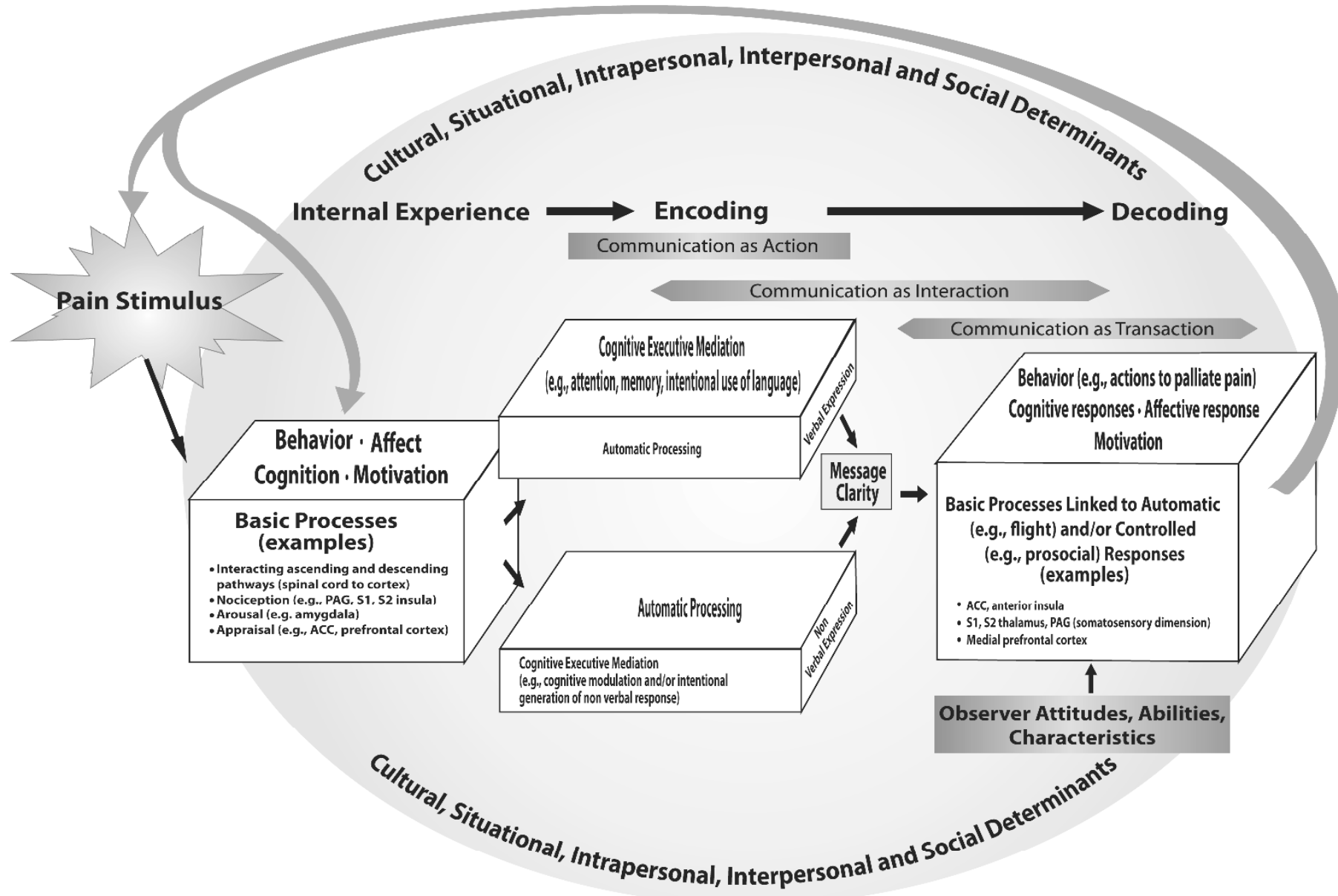Figure 1: The Traditional Biopsychosocial Framework

Figure 2: The Communications Model of Pain. ACC=Anterior cingulate cortex; S1=Somatosensory area; S2=Second somatosensory area; PAG=Periaqueductal gray.