EXPRESSING PAIN: THE COMMUNICATION AND INTERPRETATION OF FACIAL PAIN SIGNALS

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ABSTRACT: This article reviews recent theory and research on the origins, nature, and meaning of facial expressions of pain. A general model of pain expression, distinguishing experiential, encoding, and decoding processes involved in pain episodes, is proposed. Variables which are known to or may affect these processes are reviewed. Relationships between elements of the model and clinical phenomena of interest to health-care workers are discussed. The implications of findings in this area for health-care workers are examined. Areas in need of research are identified.

Pain is the most common reason for seeking health care (Von Korff, Dworkin & LeResche, 1990). The ability to communicate about pain and its characteristics is of obvious importance to the sufferer. Unfortunately, an observer's decisions about the severity and nature of pain can be problematic. Three examples illustrate some of the problems. V.M. was in a motor-vehicle accident which began a history of chronic pain. Several years later she underwent a psychological examination. Wishing to create a favorable impression on the examiner, V.M. did everything in her power to suppress evidence of distress so as to be a "good patient." She was so successful that the examiner questioned the veracity of her distress. D.N. was injured at work. Movements of her arms resulted in paroxysms of pain. When examined by health professionals she would repeat these movements and assume an appearance of profound agony, leading more than one profes-

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sional to conclude that her suffering was exaggerated. T.Z. was admitted to hospital for investigation of mysterious stomach pains. Physical tests revealed nothing to account adequately for his pain, leading to the conclusion that it was "psychogenic." Treatment was prescribed based on that theory. T.Z. died as a consequence of an untreated bowel obstruction.

Elements of these examples are familiar to health-care workers. In each case, psychological and social variables affecting the individual's pain display, or the observer's judgment, made decision making difficult. Similar challenges occur in other contexts. For example, pain in preverbal infants (Craig & Grunau, 1993), during post-operative recovery, or in the cognitively impaired (T. Hadjistavropoulos & Craig, 1994) is often mistreated or neglected because it is difficult to assess. These problems highlight the importance of understanding the expressive behavior that occurs during pain.

The present article focuses on one particularly salient aspect of nonverbal behavior: facial expression. Our purpose is to review the theoretical and practical implications of research on the facial expression of pain for health-care providers.

A Model of Pain Expression

This review will be guided by a general model of pain expression. Rosenthal (1982) presented a model of nonverbal communication that served as a starting point for a specific model of pain expression. Nonverbal communication is conceived as a process in which internal experiences are communicated through behavior to the world. In this A—>B—>C model, the experience of an internal state (A) may be encoded in expressive behavior through particular features (B), permitting an observer to draw inferences (C) about the experience of the sender. By integrating Rosenthal's model with Ekman's (1977) neurocultural model of emotion and recent findings, the general model of pain communication shown in Figure 1 can be formulated.

The model describes experiential, encoding, and decoding processes that may occur during an *episode* of pain. An episode ordinarily begins with a threat to the integrity of body tissue, characterized in Figure 1 as the occurrence of a painful stimulus. The problem may be acute, as in an injury, or chronic, as in an ongoing problem such as arthritic inflammation or a compressed nerve. The tissue stress contributes to pain through nociception, the process whereby injury is transmitted to the brain and transduced into a psychological *experience*. When conditions are right,

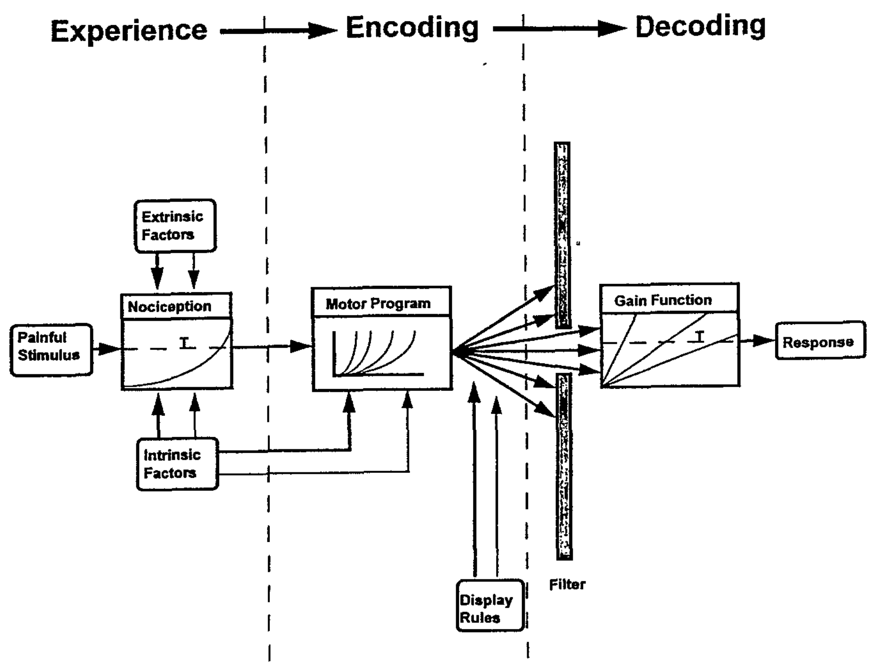

Figure 1. A model of pain expression depicting processes involved in pain experience, encoding, and decoding of pain expression. T = threshold. Arrows with heavy lines depict amplifying influences while arrows with light lines depict attenuating influences. Nociception is described as an increasing pain-intensity function. The motor program depicts varying times of onset of specific facial actions. Three examples of gain-functions varying in steepness are displayed. See text for details.

changes in facial expression *encode* information about the experience. The facial changes are "broadcast" into the social world where they may be *decoded* (detected and interpreted) by others. These observers then have various response options available to them. In each phase of this sequence, complicated physiological, psychological, and social influences affect the transmission and interpretation of information about the sufferer's state.

Factors Affecting the Pain Experience

As the first part of Figure 1 shows, when a stimulus gives rise to pain the intensity and quality of the experience can vary considerably. The determinants of the intensity of a painful experience are surprisingly difficult to elucidate, although many of the biophysical processes are well understood (cf. Wall & Melzack, 1994). The intensity of an episode of pain may reflect the degree of injury; however, relationships among the severity of tissue damage, pain experience, pain behavior, and disability are widely recognized to be inconsistent (Craig, 1994).

The extent to which a stimulus may give rise to pain is modulated by a number of factors that have been labeled *intrinsic* and *extrinsic* in the model. These variables may amplify or attenuate the effects of a noxious stimulus leading to higher or lower levels of pain. Intrinsic characteristics affecting pain intensity include factors which modify the neural transmission of pain information (e.g., aging), personality variables such as hypochondriasis or health anxiety (H.D. Hadjistavropoulos & Craig, 1994), and cognitive factors such as having a catastrophic or resourceful coping style. Extrinsic characteristics include exogenous influences such as analgesic drugs, the sensory consequences of experience (e.g., stress-induced analgesia), and other environmentally based influences such as expectations about the episode.

The inclusion of a threshold line (symbolized as "T") in Figure 1 indicates that a pain episode must achieve a certain severity before it will be evident in the face. This element in the model is necessitated by evidence that facial expression may not take place, even though pain of substantial intensity is being experienced. For example, Prkachin (1992a) examined volunteers' reactions to different types of experimental pain. At severities at which the pain was reported to be substantial, 13-50% of subjects displayed *no* facial evidence. Wilkie (1995) reported comparable findings among lung cancer patients.

These findings have several implications. There are individual differences in the extent to which facial display will be present during painful events. It is possible to endure painful events impassively. A threshold level, variable from individual to individual, must be reached before the facial display will be evident. The determinants of this threshold are largely unexplored and warrant further investigation. Finally, the experience giving rise to the expression must be substantial before the facial grimace will be observed.

Facial Encoding of Pain

When conditions are right, pain leads to changes in facial expression. Figure 1 borrows Ekman's (1977) and Tomkins' (1962) concept of the "affect program" to describe the encoding of pain in facial expression. When the pain experience exceeds the critical threshold, a central motor program leading to discrete changes in facial expression is activated. These changes consist of several actions which are generally coupled with one another, but whose temporal dynamics vary as the display unfolds.

Features of the Pain Display in Adults

The facial changes that occur during acute pain have been described well in the past decade. Several independent groups have used Ekman and Friesen's (1978) Facial Action Coding System (FACS), which allows any facial expression to be described in terms of the 46 unique actions of which the face is capable, to analyze the expressions of people in pain (see Craig, 1992, and Craig, Prkachin, & Grunau, 1992, for comprehensive reviews). Studies of adults have focused on naturally occurring reactions when the pain from injuries or disease states is exacerbated (Craig, Hyde, & Patrick, 1991; LeResche & Dworkin, 1988; Prkachin & Mercer, 1989) or reactions induced by painful experimental procedures (Craig & Patrick, 1985; Patrick, Craig, & Prkachin, 1986; Prkachin, 1992a).

These studies have shown consistently that there are reliable increases in the likelihood and intensity of a subset of the actions identifiable with FACS. The action that occurs most reliably is a tightening of the orbital muscles surrounding the eye, leading to a narrowing of the eye aperture and raising of the cheeks. The corrugator and associated muscle groups lower the eyebrows and wrinkle the bridge of the nose. The levator muscles raise the upper lip and may produce wrinkles at the side of the nose. Finally, the eyelids may close altogether. A depiction of these actions is presented in Figure 2.

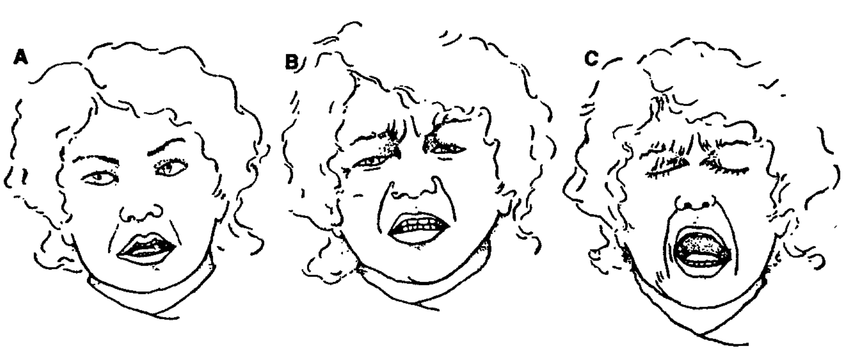

Figure 2. Portrayal of three phases in the development of a pain expression. Reprinted with permission from Prkachin (1992a).

Features of the Pain Display in Infants

Because there are adaptive advantages to being able to engage adult care from the earliest moments of life, a specialized system for communicating suffering in infants and children is to be expected. Given that facial activity is evident from birth, investigations of facial expressions as indices of pain in infants were warranted (Grunau & Craig, 1987). Using FACS adapted for infants, Craig, Hadjistavropoulos, Grunau, and Whitfield (1994) studied neonates exposed to painful and nonpainful procedures in the nursery. Brow lowering and cheek raising were the most frequently observed reactions to invasive medical procedures. Horizontal pulling of the lip corners and dropping of the jaw also occurred but were less probable. Closing of the eyes did not discriminate painful and nonpainful events probably because the babies were often asleep at the time of assessment.

Grunau and Craig (1987, 1990) also adapted FACS to study pain during infancy. Of ten facial movements coded with this Neonatal Facial Coding System (NFCS), five have been associated consistently with pain in healthy newborns (Grunau & Craig, 1987; Grunau, Johnston, & Craig, 1990): brow lowering, eyes squeezed tightly shut, deepening of the nasolabial furrow, open lips and mouth, and a taut cupped tongue. Variations in these actions have been observed among pre-term infants (Craig, Whitfield, Grunau, Linton, & Hadjistavropoulos, 1993), and in comparisons of two-month-old, pre-term, and full-term infants studied shortly after birth (Johnston, Stevens, Craig, & Grunau, 1993). These observations highlight the morphological similarity between adults and infants in the response to pain.

The availability of evidence about pain in this population is important because increased morbidity and mortality rates occur among neonates subjected to surgery without adequate analgesia (e.g., Anand & Hickey, 1992). Consequently, use of the NFCS, which provides a criterion measure for morphine analgesia in pre-term neonates (Scott et al., 1994), may play a role in preventive intervention.

Properties of Pain Expressions

The set of facial changes described in adults and children appears to be specific to pain. The actions associated with pain differ from those accompanying other affective states (Ekman & Friesen, 1975). LeResche (1982) found that although the pain display shared some common facial actions with fear, anger, and sadness, the overlap between these states and pain was minimal. Similarly, Boucher (1969) found that judges were able to discriminate expressions of pain from displays of other emotional states. LeResche and Dworkin (1988) found no relationship between measures of pain expression and indicators of the emotional states their patients were suffering, concluding that the pain expression taps specific qualities of pain, rather than other dimensions of psychological distress.

Factor analyses also imply that these actions may properly be termed a pain "expression." Prkachin (1992a), for example, found that the four most reliably observed actions loaded on the same general factor across four different kinds of pain.

Although the changes involved in this expression vary in intensity and in the number of actions recruited, the concept of a "prototypical" pain expression seems valid and useful. The actual behavior observed during a painful episode will likely be a variety of the basic core of actions along with a limited range of other actions; an expression that perhaps is better characterized as a "fuzzy" set rather than invariant. These expressions have in common with emotional expressions the property of being fleeting (Ekman, 1984). When they occur they are brief, lasting for two or three and rarely more than five seconds. Prkachin (1992a) and Prkachin, Berzins, and Mercer (1994) describe ways of combining measures of these actions to provide indices of pain expression.

Figure 1 indicates that just as intrinsic factors might affect pain expression by modulating the pain experience, it is also possible that they may affect the motor program directly. Evidence to this effect comes from two sources. Prkachin (1992a) found that there was consistency in the intensity of pain expressions across four pain modalities (Pearson *r*s from .30-.35), suggesting that people may show a modestly stable tendency to be expressive or unexpressive of pain. In a study of shoulder pain sufferers, Prkachin, Solomon, Hwang, and Mercer (1995) were able to distinguish patients whose pain expression was consistent with their verbal reports of pain from those whose expressions and reports were inconsistent. This also implies that personal characteristics may affect pain expression independent of effects on the pain experience. This possibility has considerable practical importance, since desynchrony between pain experience and expression in patients has obvious implications for problems in clinical communication.

Modulation of the Pain Display

Many quandaries confronting clinicians who work with pain sufferers may be understandable using the concept of display rules (Ekman & Friesen, 1969a). Display rules represent the impact of sociocultural factors and the immediate context on facial expression. These variables play a major role in modulating pain expression. Indeed, learning how to control pain display (to be a "good soldier," or to "grin and bear it") is a main theme in social development (Craig, 1986).

As with emotional expressions, there are several ways in which display rules may operate. A person may attenuate, exaggerate, or "mask" the display. Much clinical lore surrounding pain patients contains speculation about display rules. Treatment decisions are sometimes based on these implicit theories. One explanation of real and putative ethnic differences in pain expression is that different groups provide different consequences for pain display. But stereotypes fail to recognize tremendous within-group variations and small between-group differences which call into question their utility (Craig & Wyckoff, 1987). Another issue concerns people whose suffering appears to qualify them for financial compensation or release from normal obligations. Clinicians, adjudicators, insurance investigators, and family members often propose that the financial or social consequences of pain displays, rather than the experience of suffering, represent their true sources. Because interpretations are subject to error, and their ramifications are potentially very serious, understanding how display rules affect pain expression is crucial.

One question that has received some attention is whether it is possible to detect the operation of display rules. Neuropsychological evidence on the control of facial expression is consistent with this possibility. Rinn (1984) described two partially independent motor systems that influence facial expression. One is largely involved in consciously mediated, deliberate movements, the second in spontaneous movements. These neuroanatomical factors might affect deliberate control of pain expression. Ekman & Friesen (1969b) similarly proposed that attempts to modulate facial expression (e.g., by suppression or masking) may be unsuccessful, leading to "nonverbal leakage"—the display of signals that betray the true underlying state, presumably via similar mechanisms.

Recent studies have addressed these issues by manipulating display rules directly. Craig, Hyde, and Patrick (1991) examined back pain patients undergoing a physiotherapy examination. Movements that produced pain were performed under standard conditions and when the patients were asked to suppress pain expression or to fake pain. Observers' ratings of the displays indicated that patients were quite successful at dissimulating and masking pain expression (Poole & Craig, 1992). However, analyses based on FACS measurements implied that patients' faked and exaggerated reactions were "caricatures" of the genuine response (Craig et al., 1991; H.D. Hadjistavropoulos & Craig, 1994). Prkachin (1992b) contrasted healthy volunteers' spontaneous and faked reactions to electric shock. Observers judged simulations of submaximal pain to be more intense than the genuine reactions; however, when pain was severe, genuine and simulated reactions appeared comparably intense. Nevertheless, at these levels observers were able to discriminate genuine and deliberate expressions reliably. This suggests that consciously produced pain expressions differ from spontaneous expressions with respect to their apparent intensity and topographic features. These differences could involve "insertion errors" (the presence in deliberate expressions of actions that are absent in spontaneous expressions), "omission errors" (the absence in deliberate expressions of actions present in spontaneous expressions), or differences in temporal aspects of the expressions (rise time, duration, decay time, or coordination). Further evidence of the impact of display rules has been found in analyses of suppressed pain expressions. Craig et al. (1991) found that when patients attempted to suppress pain, narrowing of the eye opening, one of the "core" pain actions, was still likely to occur. H. Hadjistavropoulos and Craig (1994) also found differences in the degree of mouth opening under these conditions.

Decoding Processes

Pain expressions are social behavior that may serve several functions (Craig, 1992; Prkachin, 1986). They help solicit aid and warn of danger. They undoubtedly play an important role in eliciting sympathy and in the formation of interpersonal ties. An important distinction can be made between what the face does and how it is processed by observers (Poole & Craig, 1992). A comprehensive model of pain communication must address the different skills and sensitivities implicit in observers' responses to pain in others.

Figure 1 indicates that pain expression is "broadcast" to the social world in the facial configurations described above. It is helpful to distinguish three elements of the impact of pain expression on observers: 1) detecting and discriminating available information, 2) attaching meaning to that which has been perceived, and 3) the behavioral reaction. Ultimately, an observer may make a *behavioral response* to the pain display: rendering aid, expressing sympathy, perhaps ignoring the display altogether. With the exception of ignoring, these actions presuppose that the display has been *perceived* and *interpreted.*

Judges can discriminate differing severities of pain in adults by making use of the specific facial actions outlined above. For example, Patrick et al. (1986) reported a mean multiple R of .74 between judgments of pain and

FACS-coded facial actions. Similarly, 49% of the variance in adult judgments of the distress of newborns was accounted for by NFCS-coded pain actions (Craig, Grunau, & Aquan-Assee, 1988).

Observers' abilities to use facial displays to assess pain comes as no surprise. There are many obvious examples where access to health care is mediated by others taking action on evidence of suffering. Less self-evident is the position taken in our model that the use of available information is less than optimal. We posit that as the sufferer's experience is broadcast, there is a loss of information transfer. There is no guarantee that pain expression will be detected by the observer or that the observer will be able to draw appropriate conclusions about the state of the sufferer. These elements of the model reflect recent findings of individual differences and systematic biases in observers' judgments of pain in others.

Prkachin et al. (1994) found evidence that observers are less effective than they might be at drawing inferences about a sufferer's pain. Relationships among FACS-coded facial displays, self-reports of pain, and observers' judgments about the pain experienced by patients with shoulder injuries were examined. When pain was severe, relationships among the three measures were correlated. However, when the pain was submaximal, observers' and patients' ratings were unrelated, even though patients' ratings and indices based on facial measurement remained highly correlated. Thus, observers may have difficulty drawing inferences about a sufferer's internal state, even though evidence is manifest in the display. Similar discordance between available information and observers' inferences has been found in other areas of nonverbal communication research (Ekman & O'Sullivan, 1991).

Higher-order cognitive interpretations and judgments also may be less than optimal as, once information has been transmitted and received, observer attributes, such as varying skills, sensitivities, and dispositions, may lead to characteristic errors concerning the sufferer's internal state. Cognitive biases have been included in the model in the form of a "filtering" mechanism which "tunes out" certain signals, weighs them differently in importance, or misconstrues their meaning. These response biases may have important implications for accounts of pain in everyday and clinical settings. At the simplest level, they may lead to over or underestimation of the suffering of others. The model proposes that each observer's perception of another's pain can be characterized by a gain function which may amplify or attenuate his or her estimate of the evidence about pain coming from the sufferer. When the evidence available in the facial display exceeds a critical value on the gain function the observer is likely to conclude that pain is present or intense. Some observers have a steep gain function, in which case they will report pain in others on the basis of minimal evidence; others may have a gradual gain function, requiring substantial evidence before concluding that someone else is suffering.

This element is included in the model because of evidence that observers tend to show an underestimation bias. For example, in the study by Prkachin et al. (1994) observers' ratings and patients' ratings of the patients' pain were performed on the same scale. Observers' ratings were systematically lower than patients' by some 50-80%. Landers (1990) summarized evidence that clinicians tend to attribute less pain to patients than the patients attribute to themselves. H.D. Hadjistavropoulos, Craig, Grunau, and Johnston (1994) reported that adults attribute relatively low levels of pain to babies undergoing needle injections.

There is reason to believe that this bias may be ecologically meaningful instead of a methodological curiosity. Two recent studies examined whether differences in the perception of pain expressions could be found in groups which have had varying experiences with pain displays (Prkachin et al., 1995). In one study, observers who had lived with someone suffering from chronic pain were compared with observers who had not had this experience. These people viewed videotapes of shoulder pain and rated the pain observed. Although both groups showed an underestimation bias, it was significantly diminished among people who had lived with a pain patient. A further study compared observers with no experience with pain problems with experienced clinicians who routinely work with pain sufferers. In contrast to the previous study, the clinicians showed an *exaggerated* underestimation bias, relative to those with little experience. Though correlational, the data suggest that clinical experience with pain patients may enhance the tendency to underestimate sufferers' pain. Other findings are also consistent with this suggestion. For example, Von Baeyer, Johnson, and McMillan (1984) reported that experienced nurses were less likely to identify a facial display as signifying pain than inexperienced nurses. Other causal mechanisms are, of course, possible. There may be selection for these characteristics among clinicians. Alternatively, clinical experience may inure people to evidence of suffering over time.

Observer judgments also reflect characteristics of suffering individuals that should be unrelated to the pain being expressed. For example, H.D. Hadjistavropoulos, Ross, and Von Baeyer (1990) found that physicians' judgments of pain and their willingness to deliver care varied with the physical attractiveness of the sufferer. Attractive patients were perceived to be in less pain and to warrant less care. T. Hadjistavropoulos, McMurtry, and Craig (in press) found these biased perceptions to be unrelated to patient functioning. Interactions between observers' dispositions and sufferers' characteristics have also been reported. Von Baeyer et al. (1984) reported that nurturant women were more likely than non-nurturant women to react with solicitude to expressive patients. Suspicions of malingering may also have a substantial impact on judgments. For example, Keefe and Dunsmore (1992, p. 97) observed, "Conscious efforts to communicate pain through guarded movements, facial expressions, or extreme ratings of pain upset and even enrage clinicians."

Conclusions

There has been considerable progress in the study of pain expression in the past decade. The model of pain communication outlined here emphasizes the necessity of viewing pain expression as a transactional process. While the model is consistent with current evidence on the nature, determinants, and effects of pain expressions, it also highlights fruitful areas for further investigation. For example, although individual differences undoubtedly influence pain expression, the mechanisms whereby they operate require further inquiry. Similarly, evidence that observers, even those who have had significant experience with pain problems, make less than optimal use of pain expressions invites research into whether training protocols can be developed to alter the way in which they process pain information.

The model and the findings on which it is based have several implications for health-care professionals or others who have a stake in understanding the expression of pain. First, information about pain is conveyed by a relatively discrete set of changes in facial expression. These actions provide a valid and potentially sensitive indication of pain. Second, pain expression tends to occur when the sufferer's estimate of the subjective experience is fairly high. Hence, expression might be seen as a "late" signaling system. Health care workers ought to be aware that if pain is being expressed, chances are good that, from the sufferer's point of view, the experience is intense. By contrast, the absence of a display cannot be interpreted as indicating that there is no pain. This is related to the third implication, which follows from the evidence that observers tend to underrate pain, based on facial expression. Observers need to be aware of this bias and take it into account when important decisions may follow upon their evaluation of another's suffering. Fourth, although it may be possible to detect attempts to modulate pain display, the current state of knowledge is insufficient to allow firm conclusions to be drawn about the sources and meaning of such attempts. The importance of these issues and the amount that we do not know justifies continued attention to this area.

References

Anand, K. J. S., & Hickey, P. R. (1992). Halothane-morphine compared with high-dose sufentanil for anesthesia and postoperative analgesia in neonatal cardiac surgery. *New England Journal of Medicine, 326*, 1-9.

Boucher, J. D. (1969). Facial displays of fear, sadness and pain. *Perceptual and Motor Skills, 28*, 239-242.

Craig, K. D. (1986). Social modeling influences: Pain in context. In R. A. Sternbach (Ed.), *The psychology of pain* (2nd ed.) (pp. 67-96). New York: Raven Press.

Craig, K. D. (1992). The facial expression of pain: Better than a thousand words? *American Pain Society Journal, 1*, 153-162.

Craig, K. D. (1994). Emotional aspects of pain. In P. D. Wall & R. Melzack (Eds.), *Textbook of pain* (3rd ed.) (pp. 261-274). Edinburgh: Churchill Livingstone.

Craig, K. D., & Grunau, R. V. E. (1993). Neonatal pain perception and behavioral measurement. In K. J. S. Anand & P. J. McGrath (Eds.), *Neonatal pain and distress* (pp. 67-105). Amsterdam: Elsevier.

Craig, K. D., Grunau, R. V. E., & Aquan-Assee, J. (1988). Judgment of pain in newborns: Facial activity and cry as determinants. *Canadian Journal of Behavioural Science, 20*, 442-45l.

Craig, K. D., Hadjistavropoulos, H. D., Grunau, R. V. E., & Whitfield, M. F. (1994). A comparison of two measures of facial activity during pain in the newborn child. *Journal of Pediatric Psychology, 19*, 305-318.

Craig, K. D., Hyde, S. A., & Patrick, C. J. (1991). Genuine, suppressed, and faked facial behavior during exacerbation of chronic low back pain. *Pain, 46*, 161-172.

Craig, K. D., & Patrick, C. J. (1985). Facial expression during induced pain. *Journal of Personality and Social Psychology, 44*, 1080-1091.

Craig, K. D., Prkachin, K. M., & Grunau, R. V. E. (1992). The facial expression of pain. In D. C. Turk & R. Melzack (Eds.), *Handbook of pain assessment* (pp. 255-274). New York: Guilford.

Craig, K. D., Whitfield, M. F., Grunau, R. V. E., Linton, J., & Hadjistavropoulos, H. (1993). Pain in the pre-term neonate: behavioural and physiological indices. *Pain, 52*, 287-299.

Craig, K. D., & Wyckoff, M. G. (1987). Cultural factors in chronic pain management. In G. D. Burrows, D. Elton, & G. Stanley (Eds.), *Handbook of chronic pain management* (pp. 99-108). Amsterdam: Elsevier.

Ekman, P. (1977). Biological and cultural contributions to body and facial movement. In J. Blacking (Ed.), *The anthropology of the body* (pp. 38-84). London: Academic.

Ekman, P. (1984). Expression and the nature of emotion. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 319-343). Hillsdale, NJ: Erlbaum.

Ekman, P., & Friesen, W. (1969a). The repertoire of nonverbal behavior: Categories, origins, usage and coding. *Semiotica, 1*, 49-98.

Ekman, P., & Friesen, W. V. (1969b). Nonverbal leakage and clues to deception. *Psychiatry, 32*, 88-105.

Ekman, P., & Friesen, W. (1975). *Unmasking the face.* Englewood Cliffs, NJ: Prentice-Hall.

Ekman, P., & Friesen, W. V. (1978). *The Facial Action Coding System.* Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & O'Sullivan, M. (1991). Who can catch a liar? *American Psychologist, 9*, 913-920.

Grunau, R. V. E., & Craig, K. D. (1987). Pain expression in neonates: Facial action and cry. *Pain, 28,* 395-410.
Grunau, R. V. E., & Craig, K. D. (1990). Facial activity as a measure of neonatal pain perception. In D. C. Tyler & E. J. Krane (Eds.), *Advances in pain research and therapy. Proceedings of the 1st International Symposium on Pediatric Pain* (pp. 147-155). New York: Raven.
Grunau, R. V. E., Johnston, C. C., & Craig, K. D. (1990). Neonatal facial and cry responses to invasive and noninvasive procedures. *Pain, 42,* 295-305.
Hadjistavropoulos, H. D., & Craig, K. D. (1994). Acute and chronic low back pain: Cognitive, affective and behavioral dimensions. *Journal of Consulting and Clinical Psychology, 62,* 341-349.
Hadjistavropoulos, H. D., Craig, K. D., Grunau, R. V. E., & Johnston, C. C. (1994). Judging pain in newborns: Facial and cry determinants. *Journal of Pediatric Psychology, 19,* 485-491.
Hadjistavropoulos H. D., Ross, M., & Von Baeyer, C. (1990). Are physicians' ratings of pain affected by patients' physical attractiveness? *Social Science & Medicine, 31,* 69-72.
Hadjistavropoulos, T., & Craig, K. D. (1994). *Pain assessment in the cognitively impaired.* Unpublished manuscript.
Hadjistavropoulos, T., McMurtry, B., & Craig, K. D. (in press). Beautiful faces in pain: Biases and accuracy in the perception of pain. *Psychology and Health.*
Johnston, C. C., Stevens, B., Craig, K. D., & Grunau, R. V. E. (1993). Developmental changes in pain expression in premature, full-term, two- and four-month-old infants. *Pain, 52,* 201-208.
Keefe, F. J., & Dunsmore, J. (1992). Pain behavior: Concepts and controversies. *American Pain Society Journal, 1,* 92-100.
Landers, J. (1990). Clinical judgments in pain management. *Pain, 42,* 15-22.
LeResche, L. (1982). Facial expression in pain: A study of candid photographs. *Journal of Nonverbal Behavior, 7,* 46-56.
LeResche, L., & Dworkin, S. F. (1988). Facial expressions of pain and emotions in chronic TMD patients. *Pain, 35,* 71-78.
LeResche, L., Dworkin, S. F., Wilson, L., & Ehrlich, K. J. (1992). Effect of temporomandibular disorder pain duration on facial expressions and verbal report of pain. *Pain, 51,* 289-296.
Patrick, C. J., Craig, K. D., & Prkachin, K. M. (1986). Observer judgments of acute pain: Facial action determinants. *Journal of Personality and Social Psychology, 50,* l29l-l298.
Poole, G. D., & Craig, K. D. (1992). Judgments of genuine, suppressed and faked facial expressions of pain. *Journal of Personality and Social Psychology, 63,* 797-805.
Prkachin, K. M. (1986). Pain behavior is not unitary. *The Behavioral and Brain Sciences, 9,* 754-755.
Prkachin, K. M. (1992a). The consistency of facial expressions of pain: A comparison across modalities. *Pain, 51,* 297-306.
Prkachin, K. M. (1992b). Dissociating spontaneous and deliberate expressions of pain: Signal detection analyses. *Pain, 51,* 57-65.
Prkachin, K. M., Berzins, S., & Mercer, S. R. (1994). Encoding and decoding of pain expressions: A judgment study. *Pain, 58,* 253-260.
Prkachin, K. M., & Mercer, S. R. (1989). Pain expression in patients with shoulder pathology: Validity, properties and relationship to sickness impact. *Pain, 39,* 257-265.
Prkachin, K. M., Solomon, P. S., Hwang, T. & Mercer, S. R. (1995). Does experience affect judgements of pain behaviour?: Evidence from relatives of pain patients and health-care providers. Manuscript submitted for publication.
Rinn, W. E. (1984). The neuropsychology of facial expression: A review of the neurological and psychological mechanisms for producing facial expressions. *Psychological Bulletin, 95,* 52-77.
Rosenthal, R. (1982). Conducting judgment studies. In K. Scherer and P. Ekman (Eds.), *Handbook of methods in nonverbal behavior research* (pp. 287-361). New York: Cambridge University Press.

Scott, C. S., Riggs, K. W., Ling, E., Solimano, A., Fitzgerald, C., Hill, M., Grunau, R. V. E., & Craig, K. D. (1994). *Morphine pharmacokinetics and pain assessment in premature newborns.* Manuscript in preparation.

Tomkins, S. S. (1962). *Affect, imagery and consciousness.* Vol. 1. New York: Springer.

Von Baeyer, C. L., Johnson, M. E., & McMillan, M. J. (1984). Consequences of nonverbal expression of pain: Patient distress and observer concern. *Social Science & Medicine, 19,* 1319-1324.

Von Korff, M., Dworkin, S. F., & LeResche, L. (1990). Graded chronic pain status: An epidemiologic evaluation. *Pain, 40,* 279-292.

Wall, P. D., & Melzack, R. (Eds.). (1994). *Textbook of pain,* (3rd ed.). Edinburgh: Churchill Livingstone.

Wilkie, D. J. (1995). Facial expressions of pain in lung cancer. *Analgesia, 1,* 91-99.