EXPERIMENTER AUDIENCE EFFECTS ON YOUNG ADULTS' FACIAL EXPRESSIONS DURING PAIN

by

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ABSTRACT

Facial expression has been used as a measure of pain in clinical and experimental studies. The Sociocommunications Model of Pain (T. Hadjistavropoulos, K. Craig, & S. Fuchs-Lacelle, 2004) characterizes facial movements during pain as both expressions of inner experience and communications to other people that must be considered in the social contexts in which they occur. While research demonstrates that specific facial movements may be outward manifestations of pain states, less attention has been paid to the extent to which contextual factors influence facial movements during pain. Experimenters are an inevitable feature of research studies on facial expression during pain and study of their social impact is merited. The purpose of the present study was to investigate the effect of experimenter presence on participants' facial expressions during pain. Healthy young adults (60 males, 60 females) underwent painful stimulation induced by a cold pressor in three social contexts: alone; alone with knowledge of an experimenter watching through a one-way mirror; and face-to-face with an experimenter. Participants provided verbal self-report ratings of pain. Facial behaviours during pain were coded with the Facial Action Coding System (P. Ekman, W. Friesen, & J. Hager, 2002) and rated by naïve judges. Participants' facial expressions of pain varied with the context of the pain experience condition but not with verbally self-reported levels of pain. Participants who were alone were more likely to display facial actions typically associated with pain than participants who were being observed by an experimenter who was in another room or sitting across from them. Naïve judges appeared to be influenced by these facial expressions as, on average, they rated the participants who were alone as experiencing more pain than those who were observed. Facial expressions shown by people experiencing pain can communicate the fact that they are feeling pain. However, facial expressions can be influenced by factors in the social context such as the presence of an experimenter. The results suggest that facial expressions during pain made by adults should be viewed at least in part as communications, subject to intrapersonal and interpersonal influences, rather than direct read-outs of experience.

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DEDICATION

In loving memory of my inspirational mother Rose Badali.

INTRODUCTION

> *The most important part of my environment is my fellowman. The consciousness of his attitude towards me is the perception that normally unlocks most of my shames and indignations and fears. The extraordinary sensitiveness of this consciousness is shown by the bodily modifications wrought in us by the awareness that our fellowman is noticing us at all. (P. 195).* William James (1884).

William James (1884) recognized other people as an important part of a person's environment and pointed out that the awareness of other people watching could lead to bodily changes. He was writing about emotions over a century ago, but his comments are applicable to pain today. Modern psychologists have challenged the pain field to look beyond conceptualizations of pain as a highly personal sensory experience resulting from injury or disease to consider pain as a complex multidimensional interpersonal perceptual experience (Craig, 2002). The Sociocommunications Model of Pain integrates consideration of both intrapersonal and interpersonal factors for understanding pain experience (Hadjistavropoulos, Craig, & Fuchs-Lacelle, 2004). The model extends its scope to consideration of the influence of these factors on pain expression and its impact on other people.

Social contextual factors in the proximate environment could impact communication in clinical settings as pain assessment is often completed in the presence of others (e.g., medical staff, family, friends, visitors, and other patients). In research contexts, experimenters are inevitable features of any study of human pain whose basic influence needs to be understood. However, the important role of the experimenter as an interactant in studies of human pain is not given as much attention as the role of the participant (Badali, Craig, & Jensen, 2004). This is unfortunate, because the impact of the experimenter as a potential social interactant merits attention. In addition to their potential impact as an audience, an experimenter may also represent a stranger and an authoritative figure, among other possibilities. Experimenter effects on pain behaviours such as verbal self-reports have been observed in pain research (e.g., Craig, Best, & Reith, 1974; Kállai, Barke, & Voss, 2004; Levine & de Simone, 1991). However, no studies of the influence of experimenters on facial expressions of pain have been undertaken.

Facial expressions are an important area of study as they provide an alternative window into pain experience, particularly in populations who are deficient in the ability to use language to describe their pain (Prkachin, 2007). Although facial expression is used as a measure of pain experience and has been shown to reflect differences in severity of painful stimulation (e.g., Kunz, Scharmann, Hemmeter, Schepelmann, & Lautenbacher, 2007), it can also reflect the complexities of the interaction of individuals with the specifics of the environments in which they find themselves (Williams & Craig, 2006). The presence of an audience can be construed as an important part of the environment and as a minimal representation of interpersonal factors. Audience effects on behaviour, when observed, reflect sensitivity to the social context (Fridlund, 1991; 1994).

We expect that the presence of an experimenter audience will have an effect on facial expression because previous research suggests that facial expression during pain differs depending on who is watching. However, the direction of effects vary, with some researchers reporting more facial expressions of pain in the presence of an observer (Sullivan, Adams, & Sullivan, 2004) and others researchers reporting fewer facial expressions of pain in the presence of an observer (Badali, 2000; Kleck et al., 1976). This research may be confounded by the necessary but sometimes unexamined impact of participants' awareness that an experimenter may also be present. Discrepancies among findings may also relate to subtle differences in operational definitions of experimental (observed) and control (unobserved) conditions. For example, social inhibition effects (conscious or unconscious restraint of facial expressions in the presence of others) were observed by researchers who surreptitiously videotaped facial expressions in their alone control group (Badali; Kleck et al.). In contrast, no effects or social facilitation effects (conscious or unconscious increase in freedom to show, or, amplification of, facial expressions in the presence of others) were observed by researchers who openly videotaped facial expressions in their alone control group (Sullivan et al.). These subtle differences in the extent to which participants may have been aware that someone would be noticing their facial expressions could have implications for the results.

The present study will focus on facial expression, and examine whether it will be influenced by the sociality of the experimental context in which participants in human pain studies find themselves. The term *sociality* refers to the degree to which the situation supposes the presence of others (Hess, Banse, & Kappas, 1995). It has also been described as the extent to which individuals can interact with each other through the auditory and visual channels of language (Wang, 2005). Participants were randomly assigned to an observed experimental condition where the participant was sitting in a room face-to-face with the experimenter (experimenter present group) or one of two control conditions. Participants were alone in both control conditions but they were led to believe that they were being unobserved in one condition (experimenter absent group) and explicitly told that they were being observed through a one-way mirror in the other condition (experimenter observing unseen condition). The latter control condition was introduced in order to explore the possibility that lack of differences between facial expressions of participants who were alone compared to those who were face-to-face with the experiment were due to the potentially social nature of the alone group (e.g., participants may suspect observation in the alone condition even if they do not report such perceptions in post experimental inquiries). A standardized pain induction procedure, the cold pressor task, was used. Facial expression was recorded surreptitiously and measured later using an objective, fine-grained component method (the Facial Action Coding System [FACS]; Ekman, Friesen & Hager, 2002) and a subjective global judgment methodology. Measures of variables (e.g., suspiciousness of observation, verbal self-reports of pain, heart rate responsiveness, cold immersion time, tendency toward impression management) that would enable examination of potential moderators and mediators of facial expression were also collected.

In summary, audience effects on human facial expressions of pain were examined in a tightly controlled laboratory setting. To the extent that facial movements are modified by social factors they may be considered as less accurate "expressions" of pain and as more complicated social signals. Demonstration of the sensitivity of facial expressions during pain to the social context would provide support for the Sociocommunications Model of Pain (Hadjistavropoulos et al., 2004). Knowledge of the specific conditions whereby audience effects on the facial expression of pain are observed and the extent to which they can account for variations in facial movements during pain has implications for research and clinical practice using facial expression as a channel of information that may provide a window into pain experience.

LITERATURE REVIEW

Overview

The following literature review addresses clinically, theoretically and empirically relevant topics. First, the definition of pain will be outlined along with the importance of studying pain from a psychological perspective. Next, the Sociocommunications Model of Pain (Hadjistavropoulos et al., 2004), a theoretical approach that can be applied to increase our understanding of a pain experience, expression, assessment and management, will be described. Subsequently, the usefulness of the Sociocommunications Model of Pain for examining facial expression in particular will be discussed (Prkachin & Craig, 1995).

Next, the literature regarding the role of social factors in modulating facial expressions will be reviewed. Evolutionary and social learning perspectives on social influence will be considered. After exploring the impact of social factors, social influence in the form of audience effects will be described. Audience effects may occur in a basic social context involving a person in pain whose face in response to a painful stimulus is visible to another person. Audience effects would be observed if the presence of an observer influences facial expressions of pain. A review of the audience effects literature and a discussion of how the demonstration of audience effects on display of the pain face would provide basic evidence of the sensitivity of pain faces to the social context will be provided.

Focusing in even more, the specific case of the experimenter as an audience in laboratory contexts will be examined. The impact of sociality (degree to which the context supposes the presence of another person) on facial expression will be investigated. Potential moderators of the impact of experimenter presence on facial expression will be explored and other methodological issues will be considered. Finally, an overview of the study rationale, method and hypotheses will be provided.

Definition of Pain

Although pain is a phenomenon that has intuitive meaning for most humans and can be identified as a psychological experience, controversies abound considering the nature and definition of pain (Craig & Hadjistavropoulos, 2004). Given the difficult nature of the task of communicating specifics regarding painful experiences, pain is often viewed as a private and subjective experience. However, the public and objective aspects of pain should not be ignored, as they are vital to our assessment and management of painful conditions in others. Social aspects of pain have been highlighted by theorists and researchers from various fields including philosophy (e.g., Ludwig Wittgenstein as discussed by Chapman, 1987), anthropology (e.g., Honeyman & Jacobs, 1996; Sargent, 1984), sociology (e.g., Bendelow & Williams, 1995), psychology (e.g., Craig, 2002; Prkachin & Craig, 1995), ethology (e.g., Eibl-Eibesfeldt, 1989), medicine (Sullivan, 2001), and neuroscience (e.g. Langford et al., 2006). The pain field is starting to extend its focus from the intrapersonal aspects of pain, viz., the experience of pain and its biophysical substrates (Craig, 2002), to acknowledge social factors.

The role of social learning (e.g., of application of the word pain through experience) is now acknowledged in the notes associated with the predominant International Association for the Study of Pain (IASP) Subcommittee on Taxonomy (1979) definition of pain as

> an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.
>
> Note: Pain is always subjective. Each individual learns the application of the word through experiences related to injury in early life. Biologists recognize that those stimuli

> that cause pain are liable to damage tissue. Accordingly, pain is that experience we associate with actual or potential tissue damage. It is unquestionably a sensation in a part or parts of the body, but it is also always unpleasant and therefore also an emotional experience. …Activity induced in the nociceptor and nociceptive pathways by a noxious stimulus is not pain, which is always a psychological state, even though we may well appreciate that pain most often has a proximate physical cause". (p.250)

Although some mention is made in the definition of notes about social learning through experience and there are some guidelines regarding what should be socially accepted as pain, the primary focus is on the importance of biological processes and psychological features (e.g., sensory and emotional components of pain). Research on pain experience, action, assessment and management again tends to focus on intrapersonal factors with less attention paid to social parameters. However, the very existence of and need for a definition of pain highlights the interpersonal importance of pain and the difficulty of communicating pain.

Importance of Studying Pain Communication

Pain is pervasive symptom that affects most individuals at some point in their lives. Based on the World Health Organization survey (Gureje, Von Korff, Simon, & Gater, 1998), the worldwide prevalence of chronic pain is in the range of 20% to 30%, with a recent survey estimating that the prevalence for Canadians is 29% (Moulin, Clark, Speechly, & Morley-Forster, 2002). The economic costs (e.g., visits to physicians and lost work days), psychological costs (e.g., increased rates of mental disorders such as depression and anxiety), and the social costs (e.g., family disruption) of chronic pain are substantial (LaChapelle, 2004). Unrelieved acute pain is also problematic, with unmitigated pain after surgery or injury resulting in more complications, longer hospital stays, greater disability, and potentially long-term pain (Canadian Pain Society [CPS], 1997).

Despite advances made in the area of pain management and our knowledge of the deleterious consequences of undermanaged pain, considerable pain is suffered needlessly (Melzack, 1988). Social communication factors, among others, may contribute to the gap between pain experience and management (Craig, Lilley, & Gilbert, 1996). For example, patient –physician communication variables (e.g., patients not knowing their options) contributed to under management of pain in cancer patients (Oliver, Kravitz, Kaplan, & Meyers, 2001). Cultural and linguistic diversities among patients and physicians (Johnson, Noble, Matthews, & Aguilar, 1999) and neurological impairments in patients (Sengstaken & King, 1993) also contribute to communication difficulties. Factors that influence the process of information transfer between people in pain and potential caregivers must be elucidated because communication is important for proper pain assessment and management (Zalon, 1993).

The extensive range of actions and formal and informal care systems designed to provide for people in pain are inherently social in nature. The relevance of the communication of pain to the effective management of pain is highlighted by the Canadian Pain Society in the following excerpts from their Position Statement on Pain Relief (1997):

> *"The best pain management involves patients, families, and health professionals."*
>
> *"Patients and families must be informed that they have a right to the best pain relief possible and encouraged to communicate the severity of their pain."*
>
> *"Health professionals have a responsibility to assess pain routinely, to believe patients' pain reports, to document them, and to intervene in order to prevent pain."*

Elucidating the factors that may influence the inaccurate communication of pain, including under-reporting and over-reporting by patients, and underestimations and overestimations by health care providers, could have practical implications. Increased understanding of the communication of pain, including the influence of social factors on pain experience and actions, as well as social interactants' pain assessments and actions, could lead to improvements in pain assessment and management, contributing to the ultimate goal of reducing human suffering associated with pain.

The Sociocommunications Model of Pain

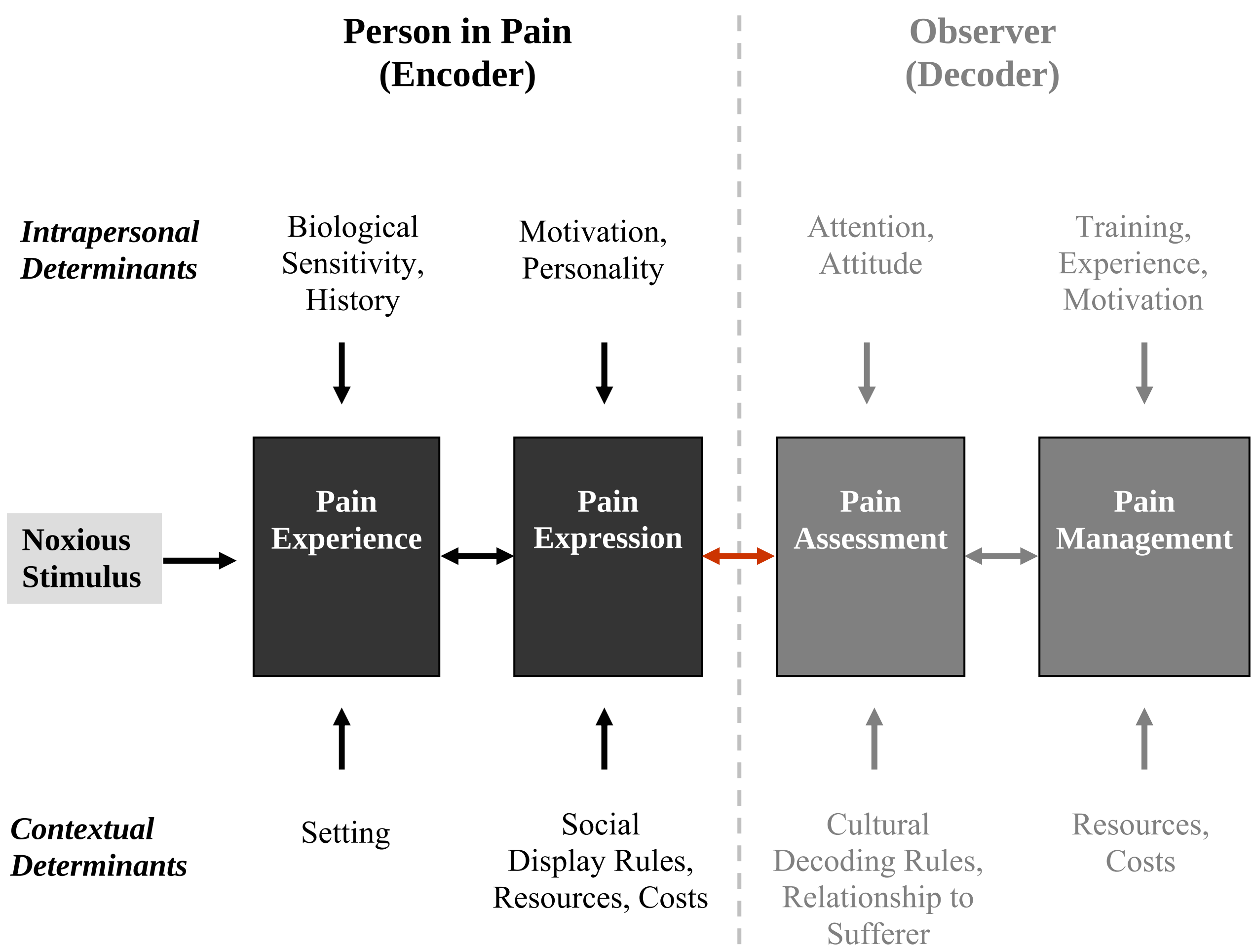
Pain experience and expression are embedded in a rich personal, social and evolutionary context, with health care and research settings representing just two modern milieus where social interaction is salient and ongoing, and where a communications model of pain is relevant. In clinical settings, a patient's pain typically is assessed by a professional in a social context that can include the presence of others such as additional staff members, family, friends, visitors, and other patients. Research contexts are no less sociable, as an experimenter, with experimental demand characteristics and participant reactivity probably in operation, assesses a participant's pain. Understanding how individuals convey and interpret information about pain has implications for the assessment and treatment of pain.

The Sociocommunications Model of Pain developed by Ken Craig and colleagues (e.g., Craig, Lilley, & Gilbert, 1996; Hadjistavropoulos & Craig, 2002; Hadjistavropoulos, Craig, & Fuchs-Lacelle, 2004; Prkachin & Craig, 1995) provides an integrated framework for conceptualizing both intrapersonal and interpersonal determinants of pain and pain control. The model incorporates the influence of social and psychological factors on the individual's subjective experience of pain, its outward display, and how interested observers interpret these actions and decide to respond behaviourally – See Figure 1. The communication process generally begins with a noxious or physically harmful stimulus that leads individuals to experience an internal state of pain. The subjective state of pain becomes manifest in diverse patterns of verbal and nonverbal activity. This component of the model is referred to as the process of *encoding* pain in features of expressive behaviour. Next, observers must be able to identify pain and accurately evaluate the nature of the person's distress. This component of the model is referred to as the process of *decoding* pain by observers who drew inferences about the encoder's experience. Finally, observers must possess the skills necessary to deliver care, and be predisposed to do so. Thus, the process of pain communication can be seen as an interpersonal matter of information transmission from internal experience through pain behaviour to social interpretation and action (central row of Figure 1).

The process of pain communication can be influenced by a host of biological, psychological, social and environmental factors. The Sociocommunications Model of Pain distinguishes between intrapersonal and contextual determinants of the interpersonal communication process. Intrapersonal determinants of the communication process are depicted in the top row of Figure 1. Intrapersonal factors contribute to pain experience (e.g., biological substrates and social learning history), pain expression (e.g., motor programs), pain assessment (e.g., attention, cognition and attitudes), and pain management actions (e.g., training and prior experience). Contextual determinants of the communication process are depicted in the bottom row of Figure 1. Contextual factors contribute to pain experience (e.g., setting and support), pain expression (e.g., social display rules or conventions for attenuating, intensifying or masking pain behaviour), pain assessment (e.g., relationship to the suffering person and social context), and pain management actions (e.g., setting).

The main purpose of this thesis was to demonstrate that variations in the sociality of the context during pain experience could influence pain encoding in the form of facial expression. To the extent that social context may influence the facial expression of pain, another goal of the present thesis was to examine the decoding component of the model to explore the effects on judgments made by naïve onlookers.

Figure 1. Sociocommunications Model of Pain



Encoding Pain in Facial Expression

According to the Sociocommunications Model of Pain, behaviours in response to pain can represent encoding of the experience of pain into public expressions of pain. Observable manifestations (e.g., paralinguistic vocalizations, motor activity, gesticulations and postural adjustments) displayed by an individual experiencing pain can communicate to others the fact that they are feeling pain (Craig, 1998; Fordyce, 1976; Keefe, Williams & Smith, 2001; McGrath, 1998). Of the different domains of pain behaviour, facial movements are of considerable interest. Prkachin (2007) noted that interest in facial expression of pain has been driven by concerns about the measurement properties of verbally based tools for assessing pain and their inapplicability to populations (e.g., infants) who cannot use language to communicate their pain. The interest in examining facial expression has also been sparked by concern over the easy manipulation of language to describe pain by persons competent to use language but attempting to manage others' impressions of them. Because facial expressions during pain are considered to be more automatic than verbal language (Hadjistavropoulos & Craig, 2002), are present in humans from birth (Izard, Huebner, Risser, McGinnes, & Dougherty, 1980), are reasonably consistent across painful stimuli (Prkachin, 1992), are often severity-dependent (Kunz et al., 2007), are difficult to voluntarily suppress in response to severe pain with sudden onset (Chapman & Jones, 1944), and are difficult to accurately voluntarily produce in the absence of pain (Hill & Craig, 2002), the uses of facial expression as a pain measure for people with verbal communication difficulties and as a clue to deception in verbal populations are of interest.

The face is well prepared for nonverbal communication at birth, with all the important muscles needed for expressions well developed (Ekman, 1982). Evidence supporting this assertion is available from primatological studies indicating homologies between primate and human facial expressions (Chevalier-Skolnikoff, 1973), human ethological research on facial expressions of blind and deaf children (Eibl-Eibesfeldt, 1989), cross-cultural research on facial expressions (Eibl-Eibesfeldt, 1989; Ekman & Friesen, 1971), and psychophysiology of the human face (Dimberg, 1982).

Research evidence suggests that, with some variation, a relatively distinct subset of facial actions is recognizable as an expression of pain in humans across the lifespan (Craig, Prkachin, & Grunau, 2001; Williams, 2002). Muscle actions associated with pain have been identified and quantified in component studies using detailed facial coding systems such as the Neonatal Facial Coding System (NFCS; Grunau & Craig, 1987) in infants, the Child Facial Coding System (CFCS; Chambers, Cassidy, McGrath, Gilbert, & Craig, 1996) in children, and the Facial Action Coding System (FACS; Ekman & Friesen, 1978) in adults. Discernable and relatively specific facial expressions are associated with pain in full term and preterm human neonates (Craig, Whitfield, Grunau, Linton, & Hadjistavropoulos, 1993; Grunau & Craig, 1987; Hadjistavropoulos, Craig, Grunau, & Johnston, 1994; Oberlander et al., 2000; Stevens, Johnston, & Horton, 1994), children (Chambers et al., 1996) and adults (e.g., Craig, Hyde, & Patrick, 1991; Hadjistavropoulos & Craig, 1994; Hill & Craig, 2002; LeResche & Dworkin, 1984, 1988; Prkachin, 1992; Prkachin & Mercer, 1989). Core features include lowering the brow, narrowing the eyes by tightening the lids and raising the cheeks or even fully closing the eyes, raising the upper lip, deepening the nasolabial fold and wrinkling the nose (see Table 1).

Table 1

Facial Actions Associated with Pain: A Lifespan Perspective

Muscle Basis	Infants (NFCS)	Children (CFCS)	Adults (FACS)
Depressor Glabellae, Depressor Supercilli, Corrugator	Brow Bulge	Brow Lower	Brow Lowering
Orbicularis Oculi, Pars Orbitalis, Pars Palebralis	Eye Squeeze	Eye Squeeze, Cheek Raiser, Squint	Cheek Raise, Lid Tighten, Eyes Closed
Levator Labii Superioris, Alaeque Nasi, Caput Infraorbitalis	Nasolabial Furrow	Nose wrinkler, Upper Lip Raise, Nasolabial Furrow	Nose Wrinkle, Upper Lip Raise

Note. NFCS = Neonatal Facial Coding System (Grunau & Craig, 1987).
CFCS = Child Facial Coding system (Chambers, Cassidy, McGrath, Gilbert, & Craig, 1996).
FACS = Facial Action Coding System (Ekman & Friesen, 1978).

In adults, the most parsimonious and empirically supported set of facial actions of pain was reported by Prkachin (1992), who demonstrated that four facial actions (brow lowering; orbital tightening; levator contracting and eyes closing) coded using FACS (Ekman & Friesen, 1978) provided the bulk of information about pain across a variety of experimentally induced pain stimuli (e.g., cold pressor, ischemic, electric shock and pressure). In adults, this pattern of behaviour is consistent across a range of experimental pain stimuli (Badali, 2000; Craig & Patrick, 1985; LeResche, Dworkin, Wilson, & Ehrlich, 1992; Patrick, Craig, & Prkachin, 1986; Prkachin, 1992), and clinical pain conditions (Craig et al., 1991; Hadjistavropoulos & Craig, 1994; LeResche, 1982; LeResche & Dworkin, 1988; Prkachin & Mercer, 1989), although these descriptions are based largely on responses to acute pain or exacerbation of pain in individuals with chronic pain conditions. In summary, a set of facial actions that typically occur in response to pain has been identified.

Decoding Pain from Facial Expression

Within a Sociocommunications Model of Pain, facial actions are regarded as communicative acts that can provide information to another party. If facial expressions of pain have visual communicative value, it would be expected that observers could use facial actions to judge pain with some success. People use facial activity when making judgments about others (Ekman & Rosenberg, 1997). Results from studies investigating the ability of observers to accurately detect pain are mixed, although there are indications that observers detect more than they can confidently report. While some studies suggest observers are reasonably accurate, able to make coarse distinctions among patients' pain states (Prkachin, Berzins, & Mercer, 1994; Lilley et al., 1996), others indicate judges underestimate (Chambers, Reid, Craig, McGrath, & Finley, 1998; Romsing, Moller-Sonngergaard, Hertel, & Rasmussen, 1996; Sutherland et al., 1988) or overestimate pain, or both (Olden, Jordan, Sakima, & Grass, 1995). The divergent results may be related to the effects of patient (Chibnall, Tait, & Ross, 1997; Hadjistavropoulos, Ross, & von Baeyer, 1990; Loveman & Gale, 2000;), situational (Tait & Chibnall, 1997) and/or observer (Prkachin, Solomon, Hwang, & Mercer, 2001) effects on observers' pain judgments. This research area is further complicated by difficulties related to adequately operationally defining accuracy, as researchers only have approximate measures of another's pain and many variables may influence individuals' facial expressions of pain.

Among the several nonverbal channels of information available to the observer, facial expression is prominent (Ekman & Rosenberg, 1997; Russell & Fernandez-Dols, 1997), largely due the accessibility, plasticity and discriminability of facial expressions (Craig, Prkachin, & Grunau, 2001; Ekman & Friesen, 1975). When judging the location and severity of pain, clinicians tend to assign greater weight to nonverbal expression than to patients' self-report (Hill & Craig, 2002). Specific nonverbal behavioural measures may not be as vulnerable to social influences as other techniques (Craig, 1998; Hadjistavropoulos & Craig, 2002). Consistent with this hypothesis, Hill and Craig (2002) found that the pattern of motoric facial display during the actual experience of pain differed from the pattern for faked pain. This provides some behavioural evidence for the commonly made assumption that non-verbal behaviour is less amenable to deception (Ekman & Friesen, 1969, 1974). Furthermore, it would help explain the tendency for individuals ranging from untrained judges (Poole & Craig, 1992) to clinicians (Johnson, 1977) presented with verbal and nonverbal behaviour to consider nonverbal features a more salient or important source of information on which to base their judgments (Craig & Prkachin, 1980; 1983; DePaulo, Rosenthal, Eisenstat, Rogers, & Finkelstein, 1978; Jacox, 1980).

Social Influences on Facial Expression of Pain

Pain clinicians are primarily interested in expressions *of* pain or clues to the internal experience of another person. However, it is important to consider the extent to which expressions *of* pain may be influenced by the fact that they can be interpreted as messages *to* other people. Williams and Craig (2006) noted that "[p]ain behaviour is more than an expression of subjective experience but also reflects the complexities of the interaction of individuals with the specifics of the environments in which they find themselves" (p. 202). They challenged scientists to generate a science of pain expression that is as complex and developed as our understanding of the sources and varieties of subjective pain experience. Examination of the role of observers (key aspects of environments in which pain is experienced and assessed) in the expression of pain would be a step toward this goal.

Social Contextual Influences on Facial Expressions of Pain: An Evolutionary Perspective

Human facial expressions of pain can be considered as evolved types of social communications or strategic acts that serve to control social interactions and confer advantage on the displayer (Williams, 2002). While certain adaptive benefits of pain experience often have been described, including distinguishing harmful from harmless situations, prompting avoidance of harm and its associated cues, giving a high priority to escape from danger, inhibiting activities which might cause further tissue damage (Bateson, 1991), motivating us to action (Damasio, 1994), and making recovery the overriding priority after escape (Wall, 1999), less attention has been paid to considering functions of facial expression of pain in an evolutionary framework which includes the notion that facial expression and its detection by others are social adaptations (Craig & Badali, 2002; Goubert, Craig, & Buysse, in press; Williams, 2002).

Encoding pain into facial expression would have little social value if there were not a complementary capacity for observers to decode pain. For example, the reflex-like, automatic facial expressions associated with pain in infants would have little communicative value for infants if parents and caregivers did not pay attention to the displays and interpret them as a distress signal (Craig, Korol, & Pillai, 2002). The brain mechanisms responsible for sensitivity to the experiences of others in pain are beginning to be elucidated (Botvinick et al., 2005; Goubert et al., 2005; Simon, Craig, Miltner, & Rainville, 2006).

From an evolutionary perspective, suppression and amplification of pain behaviours according to the demands of the social situation would confer certain advantages, whether as a consequence of conscious deliberation or not. Ordinarily, the propensity for an individual in pain (encoder) to translate that experience into an observable message that could then be interpreted by someone in the social environment (decoder) who could help the sufferer, would be beneficial. On the other hand, within the context of threat or recovery, the propensity to amplify behaviour and suppress behaviour also might confer survival advantage. This represents speculation concerning the formative impact of ancestral environments on propensities to express pain.

Encoding pain experience into facial expressions may confer advantages or disadvantages to the displayer depending on the context. Wall (1999) suggested that an individual's first action priority in response to the sensation of pain is escaping a harmful stimulus, followed by limiting further damage and prioritizing recovery, and then seeking safety and relief. Facial expressions of pain may be relevant for all these priorities. For example, the eye narrowing or closing typically associated with pain may have its origins in attempts to limit damage to the eyes. Further damage may also be limited and recovery prioritized by sending a signal via facial activity to others that usual actions (e.g., walking, lifting) may cause them harm and therefore should be suspended. Finally, the ability to communicate pain via facial expression to allies could garner relief in the form of help or care from others with little expenditure of energy or exacerbation of injuries. On the other hand, facial expressions in the presence an enemy or a stranger (potential enemy) could be costly to the person in pain. Facial expressions could signal injury or other types of problems. Others may take advantage of them. Williams (2002) suggests that cognitive propensities for balancing the costs and benefits of facial signalling may have evolved.

Decoding pain experience in another person based on their facial expressions may confer advantages. To the extent that benefits to individuals of expressing pain would be derived if displays were reliably followed by observers' actions that promoted recovery and survival, protection from danger, and aid in obtaining basic requirements (Prkachin, Currie, & Craig, 1983; Prkachin, 1997), it follows that the propensity for observers to understand these signals would also have survival advantage (Craig, 2004; Deyo, Prkachin, & Mercer, 2004; Goubert et al., 2005; Williams, 2002). For allies, pain expression could signal information about potential danger and motivate toward avoidance or helping behaviour (e.g., if the likelihood of the person in pain surviving is good and the cost to observer is low, it would be to the observer's advantage to help, particularly if they share genes; this type of selection advantage has been referred to as the *currency of kin* or *reciprocal altruism)*. For antagonists, detecting pain behaviours could aid in assessment of an enemy's health status. It could also facilitate decisions regarding whether to spend resources; sensitivity to the possibility that a person may be trying to take a benefit without paying the costs (*social cheating*) would be advantageous in that it could protect individuals from repeated exploitation (Tooby & Cosmides, 1992, 1990). In sum, both the propensity of a person in pain to encode their internal experience into detectable facial expressions and of an observer to be vigilant to observable pain expressions could confer advantage on those who used them, and so are likely to have been subject to natural selection.

Social Contextual Influences on Facial Expressions of Pain: A Social Learning Perspective

According to Social Learning Theory (Bandura, 1977), most human behaviours are learned though a combination of verbal transmission of information and observation of a skilled model. Studies of social modelling influences on pain behaviour in adults demonstrate the sensitivity of pain expression (e.g., verbal reports) to the social context in laboratory settings (Craig, 1978; Craig & Best, 1977; Craig, Best, & Ward, 1975; Craig & Prkachin, 1978; Craig & Weiss, 1971). Results from studies examining the impact of social modelling on facial expression during pain are mixed. An impact of modelling on facial expression is observed in some studies of adults (Patrick, Craig, & Prkachin, 1986; Wang, 2005) and children (Goodman & McGrath, 2003). In contrast, no effects of modelling on facial expression were observed in other studies of adults (Craig & Patrick, 1985) and children (Chambers, Craig, & Bennett, 2002). The relationship of the model to learner appears to matter, with a stronger modelling effect occurring for strangers than friends in some cases (Wang, 2005).

The influence of social context on behaviour of individuals who suffer from chronic pain has also been demonstrated. For example, an investigation of the relationship between the pain behaviours of patients with chronic musculoskeletal pain and the responses of their partners, revealed that partner behaviours explained 14% of the variance in patient verbal pain behaviours and an even higher 31% of the variance in patient nonverbal pain behaviours (Romano, Jensen, Turner, Good, & Hops, 2000). As partners' solicitous behaviours increased, so did the rate of patients' verbal and nonverbal pain behaviours. Conversely, as partners' negative responses increased, the rate of patients' nonverbal pain behaviours decreased. The results on solicitous behaviours were consistent with previous studies. Solicitous responses to patient pain behaviours by significant others have been associated with higher pain ratings (Flor, Breitenstein, Birbaumer, & Furst, 1995; Flor, Kerns, & Turk, 1987; Flor, Turk, & Rudy, 1989) and more frequent pain behaviours (Kerns et al., 1991; Romano et al., 1995). These results could reflect increases in pain experience or simply less suppression of behaviours typically associated with pain. Rather than encouraging or reinforcing pain behaviour in patients, solicitous partners may simply be sending them the message that it is safe or socially acceptable for them to manifest evidence of their inner experience.

Data on the effects of negative behaviour by significant others on patient behaviour were inconsistent. Some researchers observed that more negative responses by significant others were associated with less patient pain behaviour (Faucettt & Levine, 1991). These data are consistent with hypotheses that the negative behaviour is punishing. However, reduction of patient pain behaviours does not necessarily reflect reduction in patient pain or suffering. On the contrary, more negative responses by partners have been associated with higher patient-reported pain intensity (Summers, Rapoff, Varghese, Porter, & Palmer, 1991). Still other studies found no significant associations (e.g., Kerns, Haythornthwaite, Southwick, & Giller, 1990; Turk, Kerns, & Rosenberg, 1992). Taken together, these studies provide accumulating evidence that social factors can influence pain behaviours. The direction of influence is less clear and appears to vary. This research highlights the importance of distinguishing between pain *experience* and pain *expression*.

Social Display Rules

Sullivan and colleagues (2006) observed that surprisingly little is known about the rules governing pain expression. A potentially fruitful area of study is the influence of display rules on facial expressions during pain. Display rules are social conventions for attenuating, intensifying, or masking involuntary emotional faces in public (Ekman & Friesen, 1969). The concept can be extended to study of spontaneous pain faces and is incorporated into the Sociocommunications Model of Pain as a potential determinant of pain expression (Hadjistavropoulos, Craig, & Fuchs-Lacelle, 2004). In the present day, display rules for different social contexts may vary, with suppression of pain being expected in some situations and amplification of pain being the norm in other circumstances. For example, in a cultural or religious context where pain tolerance is seen as a character building experience, facial expressions of pain may be attenuated or inhibited to the extent that no evidence of facial activity is apparent to the naked eye (Craig et al., 1996). In contrast, if an insurance settlement required that an individual manifest evidence of injury, facial expressions of pain may be exaggerated.

Deliberate modulations of facial expressions of pain in response to explicit instructions from other people have been investigated. Facial expressions are amenable to at least partial voluntary control and researchers have described characteristics of spontaneous, faked, exaggerated and suppressed facial expressions (e.g., Hadjistavropoulos & Craig, 1994; Hill & Craig, 2002). Research participants instructed to modulate pain expression (Craig, Hyde, & Patrick, 1991; Galin & Thorn, 1993; Larochette, Chambers, & Craig, 2006; Hadjistavropoulos & Craig, 1994) appear able to do so to a certain extent and usually succeed in fooling others (Poole & Craig, 1992). In response to certain types of pain (e.g., severe pain) and in some people (e.g., infants), at least some aspects of facial expression in response to pain cannot be wholly controlled (Craig, Hill, & McMurtry, 1999; Hadjistavropoulos & Craig, 1994; Hadjistavropoulos, Craig, Hadjistavropoulos, & Poole, 1996; Hill & Craig, 2002). These findings are in line with neurophysiological evidence that indicates facial expressions are under both cortical and subcortical control (Rinn, 1984, 1991) and provides a basis for asserting that both voluntary and reflexive aspects of facial expression of pain exist.

Retrospective reports of modulation of pain expression in response to display rules have also been described. In a study investigating children’s display rules for pain, Zeman and Garber (1996) found that type of audience (mother, father, peer) influenced children’s decisions to control or express their pain. Children listened to stories and reported use of display rules, reasons for their decisions, and method of expression if the story had happened to them. Children reported controlling their expression significantly more in the presence of peers than with either their mother or father or alone. Studies investigating display rules for pain in adults would be of interest.

Less is know about spontaneous social modulations of facial expressions of pain. Rather than directly manipulating a social display rule by instructing participants to modify their behaviour, or directly asking participants how they would behave in particular contexts, other researchers indirectly manipulate the sociality of the situation and infer the display rule. These experiments held to demonstrate display rules use solitary participants as controls, under the assumption that expressive behaviour in such minimally social situations is more likely to reflect the particular sensory, emotional and motivational state elicited by the stimulus than are expressive behaviours made when others are present (Ekman, 1984). The differences between facial expressions occurring when a person is alone compared to when they are in a more socially interactive situation are inferred to be related to social factors such as display rules. The similarities are inferred to be more closely related to internal experience states. Considerable information about the nature of facial expression can be gained by attempting to study displays in the relative absence of social influence by presenting a pain-eliciting stimulus while a participant is alone and unaware of being observed.

Audience Effects – The Most Basic Case of Social Influence

One of the most basic and minimal forms of social influence is the presence of another person or, when they are watching (in the case of facial expression), an audience. Fridlund (1991, 1992, 1994) uses studies of *audience effects* in nonhumans and humans to support his hypothesis that other people are the intended addressees of motive communication. Audience effects require the presence of a triad of experimental factors: (a) referrer (e.g., person experiencing pain), (b) the reference or object of the display (e.g., the pain stimulus), and (c) referee (e.g., experimenter). An audience effect is confirmed if the person in pain's display changes as a function of who is present/observing when the object of the display (e.g., an event provoking pain) is held constant. In effect the audience creates a social context in which a display may be emitted, and audience effects, when observed, indicate that the responses are context sensitive. Demonstrating that facial movements by people in response to pain differ depending on whether or not their faces are visible to another person would demonstrate that facial movements during pain are not only expressions *of* pain experience but also must be interpreted as messages *to* other people.

To the extent that facial expressions of pain have been described as more automatic and difficult to voluntary control compared to verbal language (Hadjistavropoulos & Craig, 2002), it is of interest to examine the extent to which facial expressions are modified in response to the social context.

Audience Effects on Animal Behaviour

Audience effects on animal behaviour have been observed generally and in response to painful stimuli. Animals have the ability to modulate their signalling behaviour to some degree (e.g., Doutrelant, McGregor, & Oliveira, 2001; Evans & Marler, 1991, 1994). For example, using the audience effects paradigm to examine the ability to emit or withhold a signal in the presence of the referent for that signal, Marler, Karakashian, and Gyger (1991) found that cockerels have the option of withholding signals when communication is inappropriate. They observed that alarm calling occurred significantly less when male cockerels were alone than when accompanied by a female or another male cockerel. They concluded that readiness to alarm call is strongly affected by the social context in which signal production occurs. Other research evidence supports these assertions. Sherman (1977) found that female Belding's ground squirrels are more likely to give alarm calls when kin are present. Similarly, Chapman, Chapman, and Lefebvre, (1990) found that spider monkeys alter the duration of their alarm calls in proportion to the number of kin in the vicinity. As well, captive female vervet monkeys produce more alarm calls under threat when in the presence of their own infant compared to an unrelated infant (Cheney & Seyfarth, 1980, 1985). Fridlund (1994) suggests that such audience effect studies demonstrate that the occurrence and features of many animal signals are dependent on the social context (including who the interactants are and the context of the interaction).

Audience Effects on Human Nonverbal Behaviour

It is expected that humans, like animals, would have evolved to emit, withhold and/or modulate nonverbal signals dependent on the social context. Research findings related to audience effects suggest that human nonverbal displays previously thought reflexive or emotional actually vary considerably with the presence of interactants, and with the relationship of those interactants to the displayer (Fridlund, 1994).

Audience facilitation of smiling has been noted in several studies (Chovil, 1991; Fridlund, Kenworthy, Jaffey, 1992). For example, bowlers were more likely to smile when they turned around in the lane and met the gaze of the onlookers than when they made a spare or strike (Kraut & Johnson, 1979; Ruiz-Belda, Fernández-Dols, Carrera, & Barchard, 2003). Hockey fans (Kraut & Johnson) and soccer fans (Ruiz-Belda et al.) were more likely to smile when their team scored a goal if they were with other people. Social facilitation of smiles was not limited to adult sports fans. Audience facilitation of smiling has even been noticed in response to negative stimuli. Jakobs, Manstead, and Fischer (2001) observed social facilitation of smiling in response to negative emotional stimuli. Matsumoto and Kupperbusch (2001) observed social facilitation of smiling when viewing unpleasant videoclips in participants who were high in collectivism. In contrast, audience inhibition of negative facial expressions has also been observed. Jakobs et al. (2001) observed social inhibition of expressions of sadness in response to negative emotional stimuli. Hess, Banse, and Kappas (1995) observed that the sociality of the context, the intensity of the emotion elicitor as well as the relationship between the encoder and decoder all contributed to the variance observed in facial expression.

In studies of audience effects on facial expression, the visual availability of the audience to the encoder and the encoder to the audience are important variables. Bavelas, Black, Lemery, and Mullett (1986) showed that observers' were more likely to wince at someone else's injury if the injured person made eye contact. Chovil (1991) found that listeners who could see a storyteller exhibited more facial displays than listeners to whom the storyteller was visually unavailable. Schneider and Josephs (1991) demonstrated that the frequency of smiles by preschoolers increased with the possibility of eye contact by the experimenter. Effects of audience have been noted even in infants, with 18 month-olds smiling more when their mother was looking than when her visual attention was directed elsewhere (Jones & Raag, 1989). The results support the proposition that facial displays are influenced by the sociality of the context or the extent to which individuals can fully interact in communicative situations

It is clear that social factors influence facial expressions in response to emotional stimuli. However, specific details regarding the directional impact of specific factors remain to be articulated. In an effort to reconcile the apparently contradictory sets of findings on social facilitation and social inhibition of facial expression, Buck, Losow, Murphy, and Costanzo

(1992) examined existing studies. They observed that studies showing social facilitation involved pleasant emotional stimuli and that the audience involved often had a personal relationship with the subject such as friends and peers. In contrast, studies showing social inhibition involved negative emotion, the audience involved did not have a personal relationship with the participant and the audience did not share the emotional stimulus. Fifteen years later, this pattern remains evident, with relationship status and affective valence of eliciting stimuli relevant for predictions of modulation of facial expression.

The literature on modulation of facial expression of pain is considerably less well developed than the emotions literature. Although pain is considered to be, in part, an emotional experience, it is not currently considered to be an emotion by researchers in emotion or pain fields. Examination of whether expression of pain, which is generally considered to be a negative and, by definition, unpleasant experience, in the presence of stranger who does not share the eliciting pain stimulus is highly relevant to the clinical assessment and treatment of pain. In medical contexts, the person assessing pain in a patient is considered to have a different role or status than the person in pain and is not experiencing similar pain. If Buck et al.'s (1992) predictions are correct, facial expression of pain could be inhibited in this situation, leading some medical professionals to underestimate pain.

Audience Effects on Pain Expression: Animals in Pain

Social context can influence pain behaviour in animals. In a series of studies, Langford and colleagues (2006) demonstrated modulation of behaviour in mice during pain depending on the social context. The first study examined the influence of social context on writhing behaviour in response to noxious acetic acid injection. When two mice were given an identical injection and placed in a clear cylinder together, they displayed more writhing behaviour than mice that were isolated, but only when their counterparts were cagemates. If their counterparts were strangers, less writhing behaviour occurred. When only one of two mice was given a noxious stimulus and both were placed in a clear cylinder together, writhing behaviour was displayed even less. Furthermore, they demonstrated that the effects were dependent on visual observation. Langford et al. also found that licking behaviour in response to a formalin test was altered by the behaviour of another mouse. Licking times were increased in mice receiving a low dose of formalin while observing a cagemate who had been injected with a high dose of formalin. Licking was reduced in mice receiving a high dose while observing cagemate who had been injected with a low dose. Interestingly, no significant effects were observed if the other mouse was a stranger rather than a cagemate. In a third experiment, sensitivity to withdraw from a noxious heat stimulus was influenced as much by observation of a cagemate writhing as it was by being injected with a noxious stimulus. In both cases, mice were less sensitive to pain than if they were injected or observed a cagemate. No effects were observed if the other mouse was a stranger. Taken together, Langford et al. concluded that their findings imply the communication of pain from one mouse to another.

Audience Effects on Pain Expression: Children in Pain

Audience effects on pain expressions in children have also been observed. The impact of parental presence and behaviour during medical procedures has been studied extensively (McMurtry, McGrath, Asp, & Chambers, 2007; Piira, Sugiura, Champion, & Donnelly, 2005). For example, Vervoot and colleagues (2008) observed that children generally showed more facial pain expression in the presence of their parent than in the presence of a stranger. As well, Shaw and Routh (1982) found that young children cried longer and showed more negative behaviour during injections when their mother was present as compared to when she was asked to stay in the waiting room. However, it is uncertain whether one can conclude that they experienced more pain when their mother was present. If one assumes that there is a direct translation from experience into behaviour, one would conclude that the child experienced less pain when the mother was absent. Alternatively, if one considers the influence of social context with respect to modulating pain expression, they could interpret this finding, as Shaw and Routh (1982) did, as the presence of the mother disinhibiting the expression of the child's experience or the absence of the mother inhibiting pain behaviour. This interpretation is in line with data indicating children reported being more likely to express negative affect to their mothers than to peers; they perceived their mothers would be more understanding of expressions of pain (Zeman & Garber, 1996). Indeed, Gonzalez and colleagues (1989) found that although older children showed significantly more behavioural distress when a parent was present, their reported preference of condition for future injections was for having a parent present. These results suggest that pain expression is amenable to change via social influence. In order to make the best recommendations for patients, it is important to recognize that facial expressions during pain may have multiple determinants.

Audience Effects on Facial Expressions of Pain

Data from laboratory studies indicate that pain expression associated with acute, experimentally induced pain is sensitive to the social context. Audience effects on facial expressions in response to pain have been observed in adults. Kleck and colleagues (1976) found that male students' facial expressions (measured by judges' subjective ratings) in response to painful shock were lower when they believed themselves to be observed by a peer compared to when they were alone. Congruently, Badali (2000) found that male and female students' facial expressions (measured by judges' subjective ratings) in response to a cold pain stimulus, were lower for individuals observed by a male or female peer stranger (actually a confederate) compared to students who were alone.

In contrast, Sullivan, Adams and Sullivan (2004), reported that individuals who were in the presence of a female observer showed facial expression that was *more exaggerated* (defined by the authors as *for a longer duration*) than participants who were alone, but only if the individuals were prone to high levels of pain catastrophizing (emphasizing the negative features of painful events). The audience effects observed for individuals categorized as high pain catastrophizers are in the opposite direction to observed audience inhibition effects observed by Kleck et al. and Badali. The lack of audience effects on facial expression in low catastrophizers was consistent with the null results found by Wang (2005) who observed no differences between a friend audience condition and a stranger audience condition.

A possible explanation for the lack of audience effects found in some studies may be related to the degree to which the two conditions examined (alone vs. observer; friend vs. stranger) differed in directness of ‘sociality’ (the degree to which the situation supposes the presence of others). Sullivan et al.’s alone and observed groups were aware they were being videotaped, which is in contrast to the concealed camera methodology employed by Kleck et al. and Badali. In this way, Sullivan et al.’s alone condition may be more similar to an observed condition in other studies. All participants in Wang’s study completed the cold pressor task in the explicit presence of another person, even though their relationship with that person differed. Increased understanding of the role of the sociality or directness of experimenter presence and perceptions of the social motives of the experimenter on facial expression would help us understand the discrepant results of studies investigating social influences on pain.

Taken together, findings exploring audience effects and pain suggest that at least some features of pain expression are context sensitive, with the magnitude and direction of audience effects dependent on observer (e.g., parent versus peer), participant (e.g., high versus low catastrophizer) and contextual variables (participants aware versus unaware of being videotaped).

Implicit Audience Effects

Studies investigating the influence of the presence of various interactants on facial expressions typically use an *alone* condition as a control or comparison group. When participants are alone they are considered to be less likely to deliberately control facial expressions in response to social cues given by social interactants and more likely to emit spontaneous expressions. Facial expressions made when people are alone could reflect spontaneous or involuntary read-outs of internal states. Solitary faces may also reflect "default" social motive-signalling that would have been adaptive in our evolutionary history. For example, our evolved default facial expression of pain might be expected to send a signal for help and motivate others. A common facial expression of pain observable from birth, when humans are vulnerable and dependent on other people for survival, may be the default expression and the one that people show in the presence of family members and allies. In contrast, facial expressions that could signal pain may be suppressed in the presence of antagonists or strangers (until their status as friend, foe or neutral party is established).

From a learning perspective, the default facial expression of pain displayed when people are alone may resemble the unconditioned facial response to pain (e.g., spontaneous expression similar to the one shown by infants) or a learned response that was shaped by the person's learning history. If spontaneous (unconditioned) facial expressions of pain were regularly punished (operant conditioning) or suppressed by others in the environment (vicarious learning), we would expect them to eventually occur less frequently or to a lesser extent. In contrast, if facial expressions of pain were regularly reinforced or modeled by others in the environment, we might expect to see a default expression reflecting pain. The mechanisms for facial expressions of pain when people are alone are debated (Parkinson, 2005); however, most theorists would agree that solitary facial expressions are more spontaneous, although not necessarily less socially influenced, than facial expressions occurring in the presence of other people.

Evidence from the fields of pain (e.g., Badali, 2000; Kleck et al., 1976) and emotion (e.g., Fridlund, 1991) indicates that people often make faces when they are alone. Research evidence showing that people make faces when they are alone in laboratory testing rooms has influenced the development of contemporary theories of facial expression of emotion (e.g., Buck, 1985; Fridlund, 1991) and, more recently, pain (Williams, 2002). However, studies that attempt to compare conditions where people are *alone* to *social* conditions have been criticized as being artificially dichotomous. Fridlund (1991, 1994) asserted that that imaginal interactants could never be wholly excluded.

Sociality

The term *sociality* refers to "the degree to which the situation supposes the presence of others" (Hess et al., 1995, p. 280). Sociality has also been described as the extent to which individuals can interact with each other through communication channels (Chovil, 1991).

According to Fridlund (1991; 1994), sociality can be *implicit* considering we often (a) treat ourselves as interactants (e.g., talking to ourselves), (b) act as if others were present when they are not (Chovil, 1991; Fridlund, 1991); and (c) imagine that others are present when they are not (Fridlund, Kenworthy, & Jaffey, 1992; Fridlund et al. , 1990; Fridlund, Schwartz, &

Fowler, 1984), among other cited examples. Following this logic, experimental contexts range on a continuous variable dubbed *sociality*.

Fridlund (1994) characterizes implicit audience effects as occurring when people make faces even though their interactants are elsewhere. Although evidence of direct audience effects on facial expressions associated with emotional states is readily available, less is known about implicit audience effects on facial expressions. In a study where people imagined situations in which they reported enjoying themselves either alone (low-sociality) or with others (high-sociality), they smiled more when engaging in high-sociality rather than low-sociality imagery even though self-reports of happiness were equal in the two conditions (Fridlund et al., 1990). In a study where participants viewed a pleasant videotape either alone, alone but with the belief that a friend nearby was otherwise engaged, alone but with the belief that a friend was viewing the same videotape in another room or when a friend was present, participants' smiling varied with the sociality of viewing but not with reported emotion (Fridlund, 1991). Further studies have extended these results to situations that elicit negative emotions (Fridlund, Kenworthy, & Jaffey, 1992).

Results from these studies raise concerns that an alone condition in an experimental investigation of facial expression during pain can also be considered to be social. Accordingly, efforts to determine the social impact of various people and scenarios on people's facial expressions during pain by comparing a social condition to an alone condition may be complicated by the fact that people in the alone condition are responding to perceived social cues in the environment. When participants are alone rather than in the presence of an experimenter and/or others, what differs is the sociality, or degree to which one's social engagement is related to specifiable others. Further investigating the effects of experimenter sociality would provide an important foundation for future studies examining social influences on facial expression during pain. As well, examination of the effects of experimental sociality on facial expression during pain might help us understand some of the inconsistencies in the literature to date.

Sociality of the Research Context: Experimenter Effects on Facial Expression of Pain

Any study of human facial activity during pain, regardless of the particular characteristics of the individuals studied and the experimental or clinical context, include an inevitable social element: *the experimenter.* Fridlund (1994) argued that even when steps are taken to lead participants to believe that they are unobserved (e.g., using a hidden camera), the experimenters still may constitute an implicit audience. Participants performing a task alone often infer they are monitored (Griffin, 1998; Griffin & Kent, 1998) so interactants cannot be wholly excluded just because they are not physically present (Fridlund, 1994). Simply having an experimenter absent or a participant alone in a room does not necessarily exclude experimenter factors. In a pain laboratory, experimenter sociality generally ranges from the participant being alone to the participant performing a task in the explicit presence of the experimenter.

In research contexts, experimenters are social features whose influence has largely been neglected. The social influence of experimenters on facial expression of pain needs to be understood in order to correctly interpret earlier studies of pain and to conduct studies investigating social influence. Orne (1962) and Rosenthal (1966) were among the first psychologists to empirically demonstrate the important influence of the experimental context on human behaviour. Classic concepts relevant to the social psychology of psychological research are *reactivity* (performance altered as a function of a participant's awareness) and/or *demand characteristics* (cues in the experimental situation that may influence how participants respond) (Kazdin, 1998). While experimenter demand characteristics can be minimized or controlled to a certain extent using techniques such as double-blind methodology, reactivity is more difficult to control as it is the consequence of the *mere presence* of the experimenter. With rare exceptions, research in the field of pain is conducted with the participant's explicit consent prior to the beginning of the study, and regardless of whether the experimenter is in direct contact with participants (e.g., present and recording their ratings of pain during a medical procedure) or more removed (e.g., questionnaire study), the human participant generally is aware that their pain responses are of interest to others and will be used for research purposes. Furthermore, individuals pursuing clinical care in a medical setting usually recognize that their behaviour influences their treatment, which could affect (consciously or unconsciously) their report. In any study of pain, it is expected that a human researcher (experimenter) is involved with the study so social factors are operating.

Despite the potential influence of experimenter factors, a brief survey of human research studies reported in the pain research journal published by the International Association for the Study of Pain revealed that while 100% of studies reported participant characteristics and sample size, only 52% indicated anything about who was involved with recruitment and data collection (Badali, Craig, & Jensen, 2004). Of the studies, 17% reported the number of experimenters, 4% described experimenter characteristics (e.g., number of years experience) other than occupation, and 30% reported information related to the experimenter's role in the social context in which pain measures were obtained (e.g., double-blind methodology). The relative lack of attention to the sociality of the experimental context is unfortunate as experimenters represent a salient social feature of the research environment.

Experimenter audience effects on verbal self-reports of pain have been observed. Craig, Best, and Reith (1974) observed that participants' tendency to match the model's ratings of the shocks as progressively more uncomfortable and eventually painful was more pronounced when an experimenter was physically present compared to when the procedures were automated. This study demonstrated that verbal self-reports of pain are a function not only of the proximal elicitors (e.g., pain stimulus) and the social learning factors examined (e.g., modelling) but also of whether an experimenter was present or not. As well, it appears that experimenters may have different influences depending on the pain expression modality measured (e.g., verbal self reports versus pain tolerance versus facial expression). To date, experimenter effects on facial expression during pain have not been examined in detail.

Moderators of Audience Effects on Facial Expression during Pain

Research that attends to the potential influence of experimenters is predicated on the expectation that experimenters can influence the expression of pain, with their influence mediated or moderated by intrapersonal participant and/or experimenter characteristics.

Sex

Experimenter sex may moderate the effects of an audience on facial expression during pain. The research examining effects of experimenter sex on verbal self-reports of pain has not yielded consistent results. Kállai, Barke, and Voss (2004) observed *higher* self-reports of pain intensity for male *and* female participants tested by female experimenters. In a study where experimenter sex was highlighted by selecting attractive experimenters and having them wear clothing which accentuated the stereotypical gender characteristics of masculinity and femininity (e.g., skirts and high heeled shoes for female experimenters), Levine and De Simone (1991) found that male college students reported *less pain* in the presence of an attractive female compared to an attractive male experimenter, while female students were not significantly influenced by experimenter sex. Still other researchers have found no effects of experimenter sex on reports of pain (Feine, Bushnell, Miron, & Duncan, 1991; Otto & Dougher, 1985). In sum, experimenter characteristics may affect self-reports of pain and behavioural pain tolerance and interact with participant characteristics.

Participant sex may moderate the effects of an audience on facial expression during pain. Voracek and Shackelford (2002) suggest that consequences of sex-differentiated phenomena (e.g., intrasexual competition, status-striving, and attempts at resource accumulation among males and heavier parental care and affiliativeness with children, kin, and family among females (Mealey, 2000)) may include male attempts to hide facial expression of pain and more reliable expression of pain in females. It was hypothesized that males would show less evidence of pain in the presence of an experimenter than in the absence of an experimenter. Research is needed to extend explore whether and/or to what extent facial expression during pain is related to sex and gender variables.

Self-presentation Tendencies

Individual differences in the extent to which participants can and do control expressive presentation may moderate the effects of audience on facial expression during pain. Self-monitoring theory explores the antecedents and consequences of variation in the extent to which individuals strategically cultivate public appearances (Gangestad & Snyder, 2000; Snyder, 1974, 1979). Self-monitoring theory has changed over time as empirical research accumulated, with recent theoretical conceptualizations (Gangestad & Snyder, 2000) indicating that the self-monitoring orientation measured by Snyder’s Self-Monitoring Scale (1974) reflects individual differences in the tendency to engage in, or to eschew, forms of impression management tactics that involve the construction of social appearances and cultivation of images. Whereas high self-monitors pragmatically accept (and perhaps even embrace) these appearances and images, low self-monitors may actively attempt to convey that they present no false images. According to this theory, we would expect a more direct and accurate encoding of pain experience into pain expression in low self-monitors. In contrast, in high self-monitors, we would expect the encoding of pain experience into pain expression to be influenced by social display rules to a greater extent. Examining the potential moderating effects of self-monitoring orientation on the relationship between audience sociality and facial expression could help us understand the variance in facial expression among individuals undergoing the same pain stimulus and contribute to the development of hypotheses regarding the demand characteristics or normative social impressions in the experimental context.

Given that interactions with experimenters (evaluative strangers) should elicit greater social self-presentation motives compared to an alone condition, it was hypothesized that high-self monitors would show less evidence of pain and negative affect and show more evidence of positive affect in the presence of an experimenter than in the absence of an experimenter.

Methodological Considerations

Operationally Defining Facial Expression of Pain

Harris and Alvarado (2002) criticize the previous research on facial expressions during pain for not including percentages of participants displaying particular facial actions or expressions and for tending to use summary scores rather than examining the co-occurrence of action units. These two limitations of previous research will be addressed in the present study. Unlike most previous studies in the field, the present study specifically examined the natural co-occurrence of the set of facial actions typically described as prototypical of pain. The present study examined specific patterns of facial action by operationally defining a facial expression of pain as cooccurrence of a subset of brow lowering (AU 4), orbital tightening (AU 6-7), levator contraction (AU 9-10) and eye closure (AU 43) during pain. The pain face prototype was examined in the context of emotion prototypes for disgust, anger, sadness, fear, surprise and happiness. The prototypical facial actions associated with pain and emotions are provided in Table 2 and sample photographs are provided in Figure 2.

Distinguishing Facial Expressions of Pain and Emotion

The study of emotional aspects of pain has implications for our understanding the nature of pain experience and expression. Current definitions of pain indicate that negative emotion is an essential aspect (International Association for the Study of Pain Subcommittee on Taxonomy, 1979). Chapman (2004) argues that the emotional aspect of pain, a complex psychological experience, is what differentiates it primarily from nociception, the body's response to tissue damage. Understanding of the facial expression of pain would be enhanced by examining it in the context of facial expressions typically associated with emotion. Indeed Harris and Alvarado (2002) assert that arguments such as those made by Williams (2002) that natural selection shaped specific adaptations for the production and detection of facial expressions of pain require that the facial expressions be clear and distinct from emotion expressions. However, as pain is a multidimensional experience that is also emotional, it makes sense that facial expressions during pain would bear some resemblance to emotional expressions of pain. The expression of pain shares some facial action units with several prototypical displays associated with emotions (e.g., sadness, fear, anger, disgust, and surprise), but the constellation of actions can be differentiated from these emotions using FACS (Craig, 1992; Hale & Hadjistavropoulos, 1997; LeResche, 1982; LeResche & Dworkin, 1988). Although there is still debate over how many basic emotions and expressions exist and indeed whether they exist at all (Russell & Fernandez-Dols, 1997), distinct patterns of facial activity have been observed to be associated with emotional stimulus properties, self-reports of emotional states, and social contexts (Jakobs et al., 2001). Students and health care workers can distinguish between photographs of prototypical facial expressions of pain and basic emotions (Kappesser & Williams, 2002). Furthermore, other people have different neurophysiological reactions to prototypical expressions of pain and emotion (Simon, Craig, Miltner, & Rainville, 2006).

The relationships between emotion, pain and facial expression have been studied using both component and judgment study methodologies. Two studies utilized a FACS (Ekman & Friesen, 1978) component approach to understanding the occurrence of facial actions during pain in the context of what we know about facial expressions of emotion. LeResche and Dworkin (1988) observed facial expressions of negative emotions during a painful clinical exam for twenty-eight patients with chronic temporomandibular disorder. During painful stimulation, 82% showed disgust faces, 32% showed sad faces, 14% showed angry faces, and 3% showed fear faces. No baseline data were presented so it is unclear to what extent these faces were related to aspects of the situation other than acute pain exacerbation or general chronic pain states. Hale and Hadjistavropoulos (1997) also observed distinct facial expressions of emotion in adult patients undergoing painful blood tests. Participants were more likely to show disgust faces and less likely to show happy faces during venepuncture (pain) than baseline. No differences in anger, sadness, fear or surprise faces were noted.

Hale and Hadjistavropoulos (1997) complemented their FACS component study methodology with a judgment study. Untrained judges' subjective ratings of pain, disgust, anger, fear, and happiness increased from baseline to venepuncture. Judges' ratings of sadness and surprise did not differ. In judgment studies using photographs of posed prototypical displays of pain and negative emotions, 52% of undergraduates students (Keltner & Buswell, 1996) and

59% of health care workers (Kappesser & Williams, 2002) identified the prototypical pain face photos as pain. In both studies the most common error was to misidentify the pain prototype photograph as disgust; 19.5 % of students and 18% of health care workers made this error. No other major misidentifications were reported. In a judgment study using prototypical dynamic displays of pain and emotions, researchers observed a hit rate of 74% and a correct rejection rate of 96% for pain faces (Simon, Craig, Gosselin, Belin, & Rainville, 2008). Overall, research from component and judgment studies examining facial expressions during pain supports the proposition that there is a distinct and identifiable pain face and highlights the importance of considering both the emotional component of pain and pain in the context of other emotions.

Facial expressions encountered in clinical and other settings are likely to occur as varying blends of pain and emotion expressions (Hale & Hadjistavropoulos, 1997; LeResche & Dworkin, 1988; Prkachin, 1997). Facial expression of pain also can be considered along with emotions from a dimensional perspective. Russell (1997) suggests that the primary dimensions of facial expressions are affective valence and arousal. Facial expressions characteristic of acute pain would be expected to fall in the negative affect (Feldman Barrett & Russell, 1998; (Simon, Craig, Gosselin, Belin, & Rainville, 2008) and high arousal quadrant (Simon, Craig, Gosselin, Belin, & Rainville, 2008). From a social communications perspective, a single facial action may serve a common or different communicative purpose across contexts and expressions, much as the same words could be used as components in varying dialogues to convey similar or different meanings. By studying audience effects on pain expression using detailed measures of facial activity, it is possible to also look at patterns of facial movement typically associated with emotional states and to appreciate the broader context of expressions associated with the pain experience.

Table 2

Components of Prototypical Facial Displays of Emotions and Pain

FACS	Components of Prototypical Facial Expressions						
AU	Sadness	Fear	Anger	Disgust	Surprise	Happiness	Pain
1 = inner brow raise	X	X			X		
2 = outer brow raise		X			X		
4 = brow lower	X	X	X				X
5 = upper lid raise		X	X		X		
6/7 = orbital tighten	X		X			X	X
9/10 = levator contraction			X	X			X
11 = nasolabial deepen	X						
12 = lip corner pull						X	
15 = lip corner depress	X			X			
16 = lower lip depress				X			
17 = chin raise			X	X			
20 = lip stretch		X					
23 = lip tighten			X				
24 = lip press			X				
25/26/27 = mouth open		X	X	X	X		
43 = eyes closed							X

Note: The source for facial actions involved with emotion prototypes was The Investigator's Guide to FACS (Ekman, Friesen, & Hager, 2002). The source for facial actions involved with the pain prototype was an empirical review by Williams (2002).

Figure 2. Examples of actors posing prototypical displays associated with sadness, fear, anger, disgust, surprise, happiness, and pain.

Source: This figure is adapted from Figure 2 in Simon, D., Craig, K. D., Gosselin, F., Belin, P., & Rainville, P. (2008). Recognition and discrimination of prototypical dynamic expressions of pain and emotions. *Pain, 135*, 55-64. It is used with permission from IASP (International Association for the Study of Pain).

Study Overview

The Sociocommunications Model of Pain (Hadjistavropoulos, Craig, & Fuchs-Lacelle, 2004) articulates the relevance of considering the impact of social context on pain expression by people in pain and on pain judgments made by other people. The purpose of this dissertation was to investigate the extent to which facial expressions of pain in young adults are influenced by experimenter audience conditions representing different degrees of sociality (the extent to which individuals can interact with each other through communication channels). Participants were exposed to a painful stimulus under one of three conditions (in order from least to most social with respect to potential for visual communication): (a) alone (experimenter absent group), (b) alone but with the belief that an experimenter was viewing them through a one-way mirror (experimenter observing unseen group), or (c) face-to-face with an experimenter (experimenter present group). Since unfamiliar persons are more likely to elicit self-presentation motives if they have a higher power or status, experimenters wore a white coat to signify their role. It was hypothesized that participants' facial expressions would differ depending on the sociality of the experimental context.

Participants were recruited to participate in a study of self-report and physiological responses to pain. This was done to direct participants' focus upon an interest in psychophysiology and distract them from attending to social context and facial expression. Facial expressions were surreptitiously videorecorded and later measured using the FACS (Ekman, Friesen, & Hager, 2002), a fine-grained component coding methodology.

In order to determine whether audience sociality directly influenced facial expression during pain or indirectly influenced facial expression via an impact on pain experience, verbal self-reports of pain severity, sensory intensity and affective unpleasantness were collected immediately following painful stimulation while the audience condition was held constant. Self-reports were collected in the explicit presence of an experimenter, as this is the most common context for collection of verbal self-reports in clinical contexts.

Data on participants' demographic characteristics (e.g., sex, ethnicity) and their tendency to engage in positive self-presentation (e.g., self-monitoring orientation) that may contribute to variation in pain expression were collected to ensure that randomization procedures did not produce any spurious differences between groups and to facilitate model building of factors that contribute to facial expression.

A number of factors may moderate the effects of audiences on facial expression during pain. In the present study, the moderating effects of experimenter sex, participant sex and participant self-monitoring orientation were explored. Also, to clarify the relationship between audience effects and facial expression, a number of pain-related variables as moderators were explored. Specifically, participants' cold immersion times and heart rates were examined.

If the sociality of the experimental context influences facial expressions during pain, it would be important to know whether the changes were interpreted by others as reflecting different levels of pain severity. Global ratings are an important source of information regarding the outcome humans might naturally arrive at when observing pain in another. To increase generalizability and demonstrate the potential impact of socially modulated facial expressions of pain on other people's perceptions of people in pain, a subjective judgment methodology was also employed.

The primary goal of the present study was to examine whether facial expressions during pain are partially dependent on the social context, and, whether these facial expressions can contribute to differences in assessments of pain made by other people. Underestimations of pain may lead to undermanagement of pain and augment the problem of uncontrolled pain. Elucidation of the influence of the sociality of the experimental context on the encoding of an individual's pain experience into facial expression and decoding based on facial expression has implications for the Sociocommunications Model of Pain as well as current clinical practice.

Hypotheses

Based on the Sociocommunications Model of Pain and a review of empirical literature, two hypotheses were formulated.

Hypothesis 1: Facial expressions during pain will vary depending on the sociality of the experimenter audience condition. A social inhibition effect was hypothesized because pain is unpleasant, experimenters were unknown to participants, experimenters played a different role than participants in the experimental context, and experimenters did not undergo the painful experience.

Hypothesis 2: Facial expressions during pain reflect a unique form of pain behaviour and cannot be equated with verbal self-report measures or simple read-outs of pain experience.

METHOD

Participants

A convenience sample of 60 healthy women and 60 healthy men between the ages of 18 and 25 years were recruited through the University of British Columbia (UBC) undergraduate psychology subject pool using a flyer posted in the lobby of the psychology building.

Experimenters

Two male (ages: 26 years and 23 years) and two female (ages: 26 years and 21 years) research assistants tested an equal number of participants. All experimenters identified their ethnicity as “Canadian of European origin” and their visible minority/visible majority status as “Caucasian” or “white” (visible majority). Experimenters wore a white lab coat through the entire procedure to identify their status and minimize the effect of personal dress and physical appearance. Experimenters were trained to maintain a neutral facial display during the cold pressor task and to follow a dialogue script during the experiment up until the point of debriefing.

Setting

The experiment was conducted at the Pain Research Laboratory in the UBC Department of Psychology. Participants sat in a testing room adjacent to a control room. Their facial displays were recorded surreptitiously using a video camera concealed behind a tinted window (actually a one-way mirror) covered by curtains. Curtains were drawn with the exception of a gap (< 5 cm wide) for the camera. The camera was angled toward the participant at 45 degrees from straight through the window to record events. Participants could not see reflections of themselves in the tinted window and efforts were made to minimize attention drawn to the window or curtains, except in the observing unseen condition.

Experimental Design

When psychology researchers study facial expression in laboratory settings, there are social contextual factors that may influence the participants' facial displays. At the most basic level would be the simple presence or absence of the experimenter (an audience) during the recording of facial display. Appreciating the impact of the visibility of participants to experimenters and vice versa would enhance an understanding of facial expression during pain. The levels of the independent variable, audience condition, were selected on the basis of interest in testing the impact of the effects of three commonly occurring social contexts during human pain and facial expression laboratory experiments.

Table 3 describes the different conditions manipulated to address the sociality of the experimental context. In the experimenter present condition there was obvious visibility of participant's face (encoder) to experimenter (decoder) and there was visibility of experimenter's face (decoder) to participant (encoder). This condition contrasted with the experimenter absent condition in which there was no obvious visibility of the participant (encoder) to experimenter (decoder) and there was no visibility of experimenter's face (decoder) to participant (encoder). In studies of display rules governing expressions of emotions, the alone condition (equivalent to the experimenter absent condition) is used as the control group for social presence. Improving upon this methodology, we added an additional control condition. In the experimenter observing unseen condition, there was obvious visibility of participant's face (encoder) to experimenter (decoder) and no visibility of experimenter's face (decoder) to participant (encoder). This condition was included to ensure that the audience absent condition did not merely represent a condition under which the participants thought or acted as though they were being visually observed. A fourth condition in which the participant's face was not obviously visible to the experimenter but the experimenter's face was visible to the participant was considered for inclusion. However, it was not included in the experimental design because it does not represent a commonly occurring context in experimental or clinical pain settings. There was no intention to generalize to a population of levels of audience condition so the independent variable was considered a fixed effect.

A visual sociality score was assigned to each of the three audience conditions to clarify their status on this dimension. The details are outlined in Table 3. Essentially, each condition was evaluated in terms of the following two criteria: (1) Obvious Visibility of Participant's Face to Experimenter and (2) Visibility of Experimenter's Face to Participant. The condition was assigned a score of +1 for each criterion met and a score of –1 for each criterion unmet. In this way, higher scores indicated a higher degree of visual sociality. The conditions ranked in order of visual sociality score (from least to most social) are: experimenter absent condition (visual sociality score = -2), experimenter observing unseen (visual sociality score = 0) and experimenter present condition (visual sociality score = +2).

Apparatus

Cold Pressor

A cold pressor apparatus was used to experimentally induce pain. The apparatus consisted of a commercially manufactured plastic cooler (dimensions: width = 24 cm x length = 44 cm x depth = 28 cm). It was divided into two compartments by a plastic porous screen, with ice, water and a pump on one side and water (2 +/- 1 degree Celsius) on the other. A single hand immersion protocol was employed whereby each participant lowered his or hand through a square opening in the lid measuring 15 cm^2 until the whole hand (up to the wristfold) was submerged in the cold water. A pump circulated water to prevent local warming around the hand.

Table 3

Features of Experimental Conditions

Experimenter Audience Condition	Absent	Observing Unseen	Present
Obvious Visibility of Participant's Face to Experimenter	No (-1)	Yes (+1)	Yes (+1)
Visibility of Experimenter's Face to Participant	No (-1)	No (-1)	Yes (+1)
Visual Sociality Score (based on sum of previous two rows)	-2	0	+2
Visual Sociality Rank	1 (least social)	2	3 (most social)
Observation	Concealed	Indirect	Direct
Participant informed of observation?	No	Yes	Yes
Experimenter in testing room?	No	No	Yes
Participant alone in testing room?	Yes	Yes	No

The cold pressor is a safe and widely used painful stimulus that meets the criteria important for experimental noxious stimulation (e.g., stimulus controllability, reliability, discriminability, convenience, and validity) (Hirsch & Liebert, 1998). Cold pressor pain can simulate the subjective properties of a wide variety of types of clinical pain (Chen, Dworkin, Haug, & Gehrig 1989). Moreover, Turk, Meichenbaum, and Genest (1983) indicated that compared to other forms of laboratory-induced pain, the cold pressor noxious stimulus comes closest to the quality, duration, and urgency of clinical pain.

Heart Rate Monitor

A Polar Accurex Plus ™ heart rate monitor was used to noninvasively and automatically obtain a standard heart rate recording from the participant every 5 seconds for phases one minute prior to the cold pressor and during the cold pressor. Participants did not receive feedback regarding their heart rate before or during the cold pressor task. The heart rate monitor was used to divert participant attention away from the focal experimental variables, sociality of audience condition and facial display.

Measures

Observational Measures

Facial Expression

Facial Action Coding System. Facial movements during selected segments before and during the cold pressor task were coded using the Facial Action Coding System (FACS; Ekman & Friesen, 1978; Ekman, Friesen, & Hager, 2002). FACS is a fine-grained component approach that measures visually discernible facial movements or “Action Units” [AUs]. AUs describe movement of various parts of the face, including the eyebrows, eyelids, cheeks, nose, nostrils, lips, jaw, tongue, and chin. The incidence and intensity of AUs during designated time periods were recorded.

FACS distinguishes among action units of the upper face and the lower face. Upper face AUs change the appearance of the eyebrows, forehead, eye cover fold and the eyelids. Upper face AUs include: AU 1 (Inner Brow Raiser), AU 2 (Outer Brow raiser), AU 4 (Brow Lowerer), AU 5 (Upper Lid Raiser), AU 6 (Cheek Raiser and Lid Compressor), AU 7 (Lid Lightener), AU 43 (Eye Closure), AU 45 (Blink), and AU 46 (Wink). Lower face AUs are divided into four subcategories: Up/Down actions (AUs in the lower face which move the face in an up/down direction), Horizontal actions (AUs in the lower face which produce horizontal movement), Oblique actions (AUs in the lower face which move the face in an oblique direction), and Orbital actions (AUs in the muscles orbiting the lower face which are produced by the mouth). Up/Down actions include AU 9 (Nose Wrinkler), AU 10 (Upper Lip Raiser), AU 15 (Lip Corner Depressor), AU 16 (Lower Lip Depressor), AU 17 (Chin Raiser) and AUs 25, 26, 27 (Lips Part, Jaw Drop, Mouth Stretch). Horizontal actions include AU 20 (Lip Stretcher) and AU 14 (Dimpler). Oblique actions include AU 11 (Nasolabial Furrow Deepener), AU 12 (Lip Corner Puller) and AU 13 (Sharp Lip Puller). Orbital actions include AU 18 (Lip Pucker), AU 22 (Lip Funneler), AU 23 (Lip Tightener), AU 24 (Lip Presser) and AU 28 (Lips Suck).

Based on precedents in the literature examining facial expression of pain using FACS (Hadjistavropoulos & Craig, 1994; LaChapelle, Hadjistavropoulos, & Craig, 1999; Prkachin, 1992; 2005; Prkachin & Mercer, 1989) sets of action units were combined after coding. AU 6 (cheek raiser) and AU 7 (lid tightener) were combined to form a new variable, *orbital tightening (*AU 6 or AU 7). AU 9 (nose wrinkler) and AU 10 (upper lip raiser) were combined to form a new variable, *levator contraction* (AU 9 or AU 10). AU 25 (lips part), AU 26 (jaw drop) and AU 27 (mouth stretch) were combined to form a new variable, mouth open (AU 25, AU 26 or AU 27).

Coders. Facial data from this study were scored by two trained coders who passed the FACS test of proficiency for accurate and reliable scoring administered by Ekman and colleagues. FACS training in how to identify facial behaviours based on the muscles that produce them takes approximately 100 hours. A primary coder viewed all selected videoclips and recorded all observable facial appearance changes, deconstructing each observed expression into the specific AUs associated with facial movements. A second certified coder scored a randomly chosen 20% of data to establish intercoder reliability.

Coders scored videoclips presented in random order. Coders were blinded to the nature of each clip being coded, with the obvious exceptions of sex, approximate age and visual cues as to ethnicity. Coders were able to use slow motion and stop frame feedback.

Videotaped facial display stimuli.

i) Phases, periods, and segments. Facial activity was recorded continuously during two *phases*: (a) before the cold pressor (60 seconds) and (b) during the cold pressor (up to 180 seconds). Each phase was divided into 10-second *periods*, which were comprised of 5 consecutive 2-second *segments*. The segment (2 seconds in duration) was the basic time unit of coding. Because FACS coding is labour-intensive and requires highly trained coders, only selections of the complete videorecordings for each participant were coded. Segments from up to eight non-randomly selected 10-second periods from each participant's videotape were coded. The two baseline periods from the 60 second baseline period selected for coding were: 30-20 seconds prior to cold pressor hand immersion and 10-0 seconds prior to cold pressor hand immersion. The six cold pressor periods from the up to 180 seconds of cold immersion time selected for coding (if available) were: the first 10 seconds, followed by the 10 seconds beginning each 30 seconds following the beginning of exposure, i.e., 0-10, 30-40, 60-70, 90-100, 120-130 and 150-160 seconds during cold pressor hand immersion.

ii) Calculating percent occurrence scores. Percent occurrence scores for facial activity were calculated by first dividing observed occurrence(s) of the facial action (the amount of time the facial action was actually observed) by possible occurrence(s) of the facial action (the amount of time the facial action could theoretically have been observed) and, then, multiplying by 100 to arrive at a percent score. Percent occurrence scores were calculated for baseline and pain experimental phases).

iii) Translating FACS scores into meaningful units. Although FACS scores were designed to be atheoretical and descriptive only, researchers have successfully translated individual facial actions into more meaningful units by examining patterns of response. In order to reduce the data to a manageable and meaningful set, analyses focused on empirically supported facial action configurations associated with pain and emotions. Facial displays of pain comprised four core facial actions, brow lowerer, orbital tightening, eyes close and levator contraction (denoted with the acronym "BOEL"), that were a) associated with pain consistently across different painful stimuli (Prkachin, 1992), b) identified as carrying the bulk of facial information about pain (Prkachin, 1992), and c) considered the core features of the pain face 'prototype' presented by Williams (2002). Facial displays of emotions comprised the prototypes for sadness, fear, anger, disgust, surprise and happiness described by Ekman, Friesen, and Hager (2002) (see Table 4 for a description). Recognition and discrimination of prototypical dynamic expressions of pain and these emotions and brain responses to these expressions has been described (Simon, Craig, Gosselin, Belin, & Rainville, 2007; Simon, Craig, Miltner, & Rainville, 2006).

As well, to ensure that all relevant facial actions were considered, facial actions that were not included in any of the pain or emotion prototypes were examined if they met the following inclusion criteria: (1) minimum 70% coding reliability, (2) minimum 5% occurrence, (3) associated with pain in previous research but not included in the prototype as defined and (4) reliable differences in occurrence of display were observed between baseline and pain phases. Note: Percent occurrence inclusion criteria for Non-BOEL Facial Actions was set at a minimum

5% of the pain-related time segments recorded as has been done in previous studies (Craig, Hyde, & Patrick, 1991; Craig & Patrick, 1985; Hadjistavropoulos, Craig, Hadjistavropoulos, Poole, 1996; Hadjistavropoulos, LaChapelle, Hadjistavropoulos, Green, Asmundson, 2002; Kunz, Mylius, Schepelmann, & Lautenbacher, 2004; LaChapelle, Hadjistavropoulos, Craig, 1999).

Table 4

Description of Prototypical Pain Facial Actions

Facial Action	Appearance Description
Brow Lowerer	Pulls eyebrows down and closer together. Produces deep vertical wrinkles between eyebrows and/or an oblique wrinkle or bulge running from mid-forehead above middle of eyebrow down to inner corner of brow.
Orbital Tightening	Pulls skin from cheeks and temple toward eyes, narrowing eye opening, raising cheeks, deepening infraorbital furrow, and causing bags or pouches in skin below the eyes.
Eyes Closed	Eyelids are closed to various levels of intensity. At greatest level of intensity, upper eyelid is relaxed completely (lids touch and eyes close).
Levator Contraction	Pulls skin along side(s) of nose upward causing wrinkles to appear along sides and across root of nose. Raises nostril wings and central part of upper lip causing a bend in upper lip shape.

a) Facial displays of pain.

For the purposes of this study, a contiguous display of multiple facial actions was operationally defined as co occurrence during a 2-second coding segment. This time frame was considered long enough to capture macro facial expressions. Ekman and Friesen (1969) describe macro facial expressions as those that can be easily seen and readily labeled in terms of emotion and indicated that they generally last less than a second and often only about half a second. Accordingly, 2-seconds should be a sufficient period within which to observe cooccurrence. Use of slow motion coding also enabled coders to capture any "micro" facial expressions, which by definition have duration so short that they are at the threshold of recognition unless slow motion projection is utilized (Ekman, 2003).

b) Facial displays of emotion.

Specific patterns of facial activity associated with the emotions fear, anger, disgust, happiness, sadness, and surprise have been widely studied by emotion researchers (e.g., Ekman, 1982; Ekman & Friesen, 1971; Ekman et al., 2002) and have been investigated by pain researchers (Hale & Hadjistavropoulos, 1997; LeResche & Dworkin, 1988). The combinations of AUs that typically define each emotion facial display prototype are described in Table 5 (Ekman, Friesen, & Hagar, 2002). The prototypes were selected because they contain the central and common actions for each emotion and have the best evidence for universality (Ekman, Friesen, & Hagar, 2002). As temporal contiguity is a defining feature, a face was counted as representing a specific emotion or pain whenever the representative specific combination of AUs overlapped within a 2-second segment.

Different types of smiles were also examined. Prototypical facial expressions of happiness (also commonly referred to as *felt smiles*, *Duchenne smiles*, or *spontaneous smiles*) are distinguished by a contiguous display of AU 6 (cheek raiser) and AU 12 (lip corner puller). Because both cheek raising and lip corner pulling are also frequently associated with pain, it may be that cooccurrence of these facial actions during the cold pressor task does not reflect happiness but rather is spuriously associated with pain or masks pain. Lip corner pulling (AU 12) is the most common *mask* (an action unit used to conceal an emotional expression) (Ekman, Friesen, & Hagar, 2002). It may also be used to conceal a pain expression. In an effort to disentangle smiling from pain expressions, felt smile scores were examined with the exclusionary criteria of actions units related to pain or negative expressions (e.g., AU 4, AU 9, AU 10, AU 15, AU 17, AU 43). As per Ekman and Friesen (1982), felt smiles (spontaneous expressions of positive emotion) were differentiated from false smiles (deliberate attempts to appear as if positive emotion is felt when it is not) and miserable smiles (smile accompanied by visible signs of negative emotion or acknowledgements of feeling miserable but not intending to do much about it). Miserable smiles were characterized as the occurrence of AU 12 with AU 4, AU 15 or AU 17. False smiles were characterized as the occurrence of AU 12 with intensity greater than three in the absence of a display of AU 6 (Ekman et al., 2002).

Table 5

Basic Emotion Facial Expression Prototypes

Emotion Label	Prototypes (Ekman, Friesen, & Hagar, 2002)
Sadness	(1 + 4 + 11 + 15B) or (1 + 4 + 15) or (6 + 15)
Fear	(1 + 2 + 4 + 5 + 20 + 25, 26, or 27) or (1 + 2 + 4 + 5 + 25, 26, or 27)
Anger	(4 + 5 + 7 + 10 + 22 + 23 + 25, 26) or (4 + 5 + 7 + 10 + 23 + 25, 26) or (4 + 5 + 7 + 23 + 25, 26) or (4 + 5 + 7 + 17 + 24) or (4 + 5 + 7 + 23) or (4 + 5 + 7 + 24)
Disgust	(9) or (9 + 16 + 15, 26) or (9 + 17) or (10) or (10 + 16 + 25, 26) or (10 + 17)
Surprise	(1 + 2 + 5B + 26) or (1 + 2 + 5B + 27)
Happiness	(6 + 12)

Cold Water Immersion Time

The total time in seconds from cold pressor hand immersion to removal was recorded via a timer. A ceiling of 180 seconds was imposed to guard against negative consequences of exposure to cold, as has been done in previous studies using the cold pressor task (e.g. Badali, 2000; Chen, et al., 1989 – Study VI). Also, patients' retrospective judgments of total pain are strongly related to the intensity of pain recorded during the last 3 min of procedures (Redelmeier & Kahneman, 1996). Participants were informed prior to cold water immersion that a three minute maximum would be imposed. If the participant did not withdraw his or her hand before the time limit, a pre-defined auditory signal prompted hand withdrawal. Two independent raters confirmed the cold immersion times by viewing the videotapes, which had time-sequencing superimposed upon them. The inter-rater agreement within ±1 second was 99%.

Heart Rate

Heart rate (beats per minute) was recorded in 5-second intervals for one minute prior to the onset of the pain stimulus and during the pain stimulus. The cardiovascular response was quantified as the adjusted difference between measurements of heart rate obtained during participants' exposure to the cold pressor task and the preceding recording period. Because arithmetic difference scores typically are correlated with baseline measurements (Manuck, 1994), baseline-adjusted or residualized change scores were calculated. Residualized change scores emphasize that portion of the interindividual variability seen in heart rate during the cold pressor task that cannot be predicted from knowledge of the variability that exists in heart rate and among the same individuals before pain. Heart rate was measured in order to provide an alternate purpose for the experiment. While acute pain increases heart rate (Terkelsen, Mølgaard, Hansen, Andersen, & Jensen, 2005), it is not considered a specific measure of pain in adults (Craig & Wood, 1971).

Self-report Measures

Self-report measures were all collected in the presence of an experimenter to provide a self-report measure of pain experience that may capitalize on individual differences between participants rather than being influenced by variation due to the audience condition manipulation. The choice was made to have participants provide self-reports in the presence of an experimenter because pain reports are most commonly given by a patient face-to-face with a caregiver in a clinical setting. Also, this context was hypothesized to produce less variance than a non-explicit observation context in which participants may have different conceptions of an implicit audience.

Participants completed paper and pencil measures of pain intensity, unpleasantness and quality, immediately following administration of the cold pressor task. Multiple self-report measures of pain were included to establish convergent validity, protect against any biases related to instructional sets, and facilitate analyses of multiple dimensions of pain.

Obtaining retrospective self-reports of pain immediately following the task was chosen over other methods for measuring subjective experience on a relatively continuous basis to reduce potential reactive effects of requiring continuous reports. For example, the constant demand to report on experience may interfere with the degree to which the participant becomes responsive to the stimulus, self-report during pain stimulation may increase self-consciousness and the sense of being observed which may alter behaviour as well as affect (Kleck et al., 1976), and reports may interfere with facial display. Furthermore, it is common to obtain self-reports after a pain episode in studies of the relationship between facial expression and verbal reports of experience (Ekman & Rosenberg, 1997).

For all self-report measures, participants were asked to report on the “peak intensity, worst or most pain” they experienced. This instruction was based on evidence suggesting that it is a cognitively more complex task to rate average pain experience than peak pain experience and patients' retrospective evaluations of the total pain of a procedure largely reflect the intensity of pain at the worst part of the experience (Redelmeier & Kahneman, 1996).

Visual Analog Scale

A horizontal visual analog scale (VAS) was used to measure pain severity. Participants marked their most pain during the cold pressor task on a 100 mm line anchored with verbal endpoint labels “no pain” and “worst pain possible”. Scott and Huskisson (1976) reported that visual scales with clearly delineated end points that are 10 to 15 cm in length are least open to biases. The VAS is easy to use and among the most widely used measures of pain (McGrath, 1990). Evidence suggests it is a reliable and valid ratio scale measure for chronic and experimental pain (Jensen & Karoly, 1992; Price, McGrath, Rafiib, & Buckingham, 1983).

Verbal Rating Scales

Verbal rating scales (VRS) measuring sensory intensity and affective unpleasantness dimensions of pain were administered (Gracely, Dubner, & McGrath, 1979). Ratings of the *most* or *worst* pain experienced were made by selecting one of thirteen ratio scaled adjectives depicting subjective experience of pain in each category. The scale assessing perceived unpleasantness was anchored at the extremes with the words “very intolerable” (magnitude score = 44.8) and “no discomfort” (magnitude score = 0). The scale assessing perceived sensory intensity was anchored with the words “extremely intense” (magnitude score = 59.5) and "no sensation of pain" (magnitude score = 0). Standardized scores for each word were assigned based on data from groups of previously tested individuals on which cross modality matching procedures were used to transform VRS ratings to scale scores that have ratio properties (Gracely, Dubner, & McGrath, 1979). The results of several experiments demonstrate that ratio scales of sensory and affective verbal pain descriptors are reliable (e.g., test-retest reliability Pearson r = .97) and valid (e.g., measure of correlation between word meaning determined from an individual and a similar group Pearson r = .89) (Duncan, Bushnell, & Lavigne, 1989; Gracely, McGrath, & Dubner, 1978a, 1978b). Good psychometric properties related to the measurement of clinical pain have also been shown (Dupuis, Lemay, Bushnell, & Duncan, 1988). These scales have been used as self-report measures and tools for judges in previous studies of facial display during pain (e.g., Craig & Patrick, 1985; Prkachin & Mercer, 1989; Prkachin, Berzins, & Mercer, 1994).

The Short-Form McGill Pain Questionnaire

The Short-Form McGill Pain Questionnaire (SF-MPQ; Melzack, 1987) was administered to provide data about the quality of pain that can be compared to descriptions of acute and chronic pain conditions. As well the summary scores for its components can be compared to the VAS and VRS scales to establish convergent validity. The SF-MPQ includes 15 descriptive words related to pain quality selected from the sensory and affective categories of the standard McGill Pain Questionnaire (MPQ; Melzack, 1975). Each descriptor is ranked on a scale of 0 (*none*) to 3 (*severe*). The SF-MPQ correlates highly with the major Pain Rating Indices (Sensory, Affective and Total) of the MPQ (Dudgeon, Ranbertas, & Rosenthal, 1993), is reliable, sensitive to clinical change, and has concurrent validity (see Melzack & Katz, 2001 for a review of the MPQ & SF-MPQ).

Judges' Ratings

An equal number of male (n = 6) and female (n = 6) untrained judges viewed videoclips of individuals undergoing cold pressor pain in a laboratory situation. The videoclips provided a frontal view of the participant's face during the baseline period and cold pressor task. Although general information about cold immersion time and visible demographic variables was apparent, judges were not informed about the experimental social context manipulations or hypotheses. Judges viewed the tapes in real time once and were not permitted to review any portions. Immediately after viewing each participant's videoclip, judges rated the apparent intensity and unpleasantness of the participant's pain using the same scales that participants used to self-report (VAS, VRS), with the exception of the SF-MPQ. Judges also rated facial expressivity by choosing one of the following three global descriptors: inexpressive, somewhat expressive, and very expressive. The levels of expression were assigned values of 0, 1, and 2, respectively, for quantitative analyses.

Potential clinical implications of audience effects on pain expression were explored by asking judges' to make hypothetical assessments regarding whether pain management was warranted for each participant. Judges were asked to respond to the question, "Do you think that the level of pain that you just witnessed warrants pain relief?", using a 5 point scale ranging from 0 (*definitely no*) to 4 (*definitely yes*).

Following the suggestions of Rosenthal (1987), the videoclips (one videoclip per participant; 120 videoclips total) were arranged in a blocked, counterbalanced, and random order so as to minimize practice effects and sequence-related confounds. Judges viewed clips and provided ratings in 2-hour blocks to prevent fatigue.

Rosenthal's (1987) guidelines for choosing the number of judges to employ when characteristics of encoders (e.g., participants experiencing pain) rather than decoders (e.g., observers judging pain) were of primary interest were used. To determine the approximate number of judges required, mean reliability, r, was estimated, and the desired effective reliability, R, chosen. A mean reliability of .75 was estimated based on results from a similar study (Badali, 2000), which obtained correlations above .75 for ratings of pain intensity (.88) and unpleasantness (.76) made by four naïve undergraduates judging 120 videoclips of a similar population of undergraduates undergoing the cold pressor task. Table 2.1 in Rosenthal (1987, page 10) indicates that given an estimated mean reliability of .75, and a desired effective reliability of .80, two judges were needed. Using twelve naïve judges (six males and six females), also volunteer university undergraduates drawn from the same population as the participants, to each rate videoclips of 120 participants in the present study yielded sufficient effective reliability of the mean of judges' ratings to pool the ratings (see results section for details).

Self-Monitoring

The Self-Monitoring Scale (SMS; Snyder, 1974) was used to assess individual differences in the psychological construct of self-monitoring. According to the most recent theoretical conceptualization, which was guided by a quantitative review of the literature (Gangestad & Snyder, 2000), the self-monitoring axis captured by the SMS reflects individual differences in the tendency to use impression management tactics that involve the cultivation of social images. To adequately assess the conceptual domain of self-monitoring phenomena, the original 25-item SMS was administered, so supplemental analyses could be conducted on the original, its subscales (O-D = Other-directedness; EXT = Extraversion; ACT = Acting), and the revised 18-item version (SMS-R; Gangestad & Snyder, 1985). The SMS-R total was selected as the a priori choice for inclusion into predictive models. Although multiple content domains are represented in the measure, expressive control figures prominently, with the SMS item *"I would probably make a good actor"* displaying one of the highest item-total correlations (Gangestad & Snyder, 2000).

Suspiciousness

A semi-structured interview was developed and administered to assess participants' suspicions about the experimental manipulations. Descriptive data were collected. Using a scale ranging from 0 (*not suspicious*) to 100 (*extremely suspicious*), participants rated their overall suspiciousness as well as their suspiciousness of being videotaped. Additionally, participants in the experimenter absent group rated their suspiciousness of being observed or watched on the same scale.

After provision of numerical ratings of suspiciousness, experimenters prompted responses to open-ended questions about *why* participants chose the selected number on the suspiciousness rating scale (e.g., rather than a lower or higher number). Experimenters also asked participants to recall *when* their suspicions were first aroused and to speculate *how* any suspicions may have influenced their experience or expression during cold pressor pain stimulation. After asking participants to respond in an open-ended manner, experimenters prompted participants to consider the potential influence of their suspiciousness on facial display, cold submersion time, and verbal self-reports of pain. Experimenters recorded participants' answers verbatim and asked clarification questions when appropriate.

After data collection was complete, the primary investigator first classified the responses into categories established a priori. A research assistant classified data from 20% of subjects randomly selected to establish inter-coder reliability for assignment of data to the a priori categories.

To ensure that no categories of response were missed, the primary investigator and a research assistant searched the data for emerging themes and patterns, following steps suggested by Giorgi (1985). First, the material was read to obtain an overall impression. Second, units of meaning representing different aspects of participants' retrospectively reported experiences and behaviours were identified and coded. Third, the meaning within each code group was condensed and abstracted. Finally, the contents of each code group were summarized to generalize descriptions and concepts reflecting the most common participant responses as well as responses related to the study variables (if not included in the former). The primary investigator and the research assistant initially conducted these steps independently. Only minor differences in the final descriptions and categories were observed, and these were resolved through discussions between the two coders and, when necessary, consultation with a third party. Similar approaches have been used in other studies of transcribed data related to pain and social factors (e.g., Werner et al., 2004). Once these post-hoc categories were established, the primary investigator classified participants' responses into them. To ensure reliability of classification into post-hoc categories, a research assistant also assigned data from a randomly selected 20% of participants into categories.

No participants were excluded from the study based on their responses to follow-up questions. This decision was arrived at after considering factors including the likelihood that most studies relying upon undergraduate volunteers would have them present with a relatively high level of suspiciousness (Kazdin, 1992). Additionally, inclusion of all data enabled an empirical exploration of how the experimental conditions may elicit differences in suspiciousness.

Distractor Questionnaires

Two questionnaires were administered before the cold pressor task to distract participants from the primary purpose of the experiment and provide data for investigations outside the scope of this thesis. For this purpose, participants were given two paper and pencil self-report measures; The Family Health Questionnaire (FHQ; Koutanji, Pearce, & Oakley, 1998) and The Bem Sex-Role Inventory (BSRI; Bem, 1974). Data from these questionnaires will be analyzed in a separate study.

Procedure

Written ethical approval to conduct the study was obtained from the UBC Behavioural Research Ethics Board (see Appendix I). The experiment entitled "Effects of the Cold Pressor Task on Self-Report and Physiological Measures of Pain" was publicized using a brief study description and recruitment notice with sign up sheets posted at UBC. Participants were invited to express interest in study participation by recording their contact information on the recruitment poster. Individuals who expressed interest in participating were contacted by telephone to arrange an appointment. Experimenters were instructed to minimize effects of this contact by focusing on scheduling a time rather than engaging in other conversation.

Participants were randomly assigned to one of three experimental audience conditions (Experimenter Absent, Experimenter Observing Unseen, or Experimenter Present), with the caveat that an equal number of male and female participants were tested in each experimental condition by each experimenter. Each of four experimenters was provided with two experimental packets, one labelled "female" and one labelled "male". Each packet contained fifteen concealed condition instructions (five read “absent”, five read “observing unseen”, and five read “present”). Participants were not specifically matched to the same or different ethnicity as experimenters for reasons related to methodology (e.g., would require restricting ethnic range of participants to be feasible), statistics (e.g., power and sample size considerations) and theory (ethnicity data as collected here is a relatively crude measure of cultural variability and does not consider differences in acculturation). To understand potential effects of ethnicity on the study outcome, statistical analyses were performed to establish whether a proportional number of participants from each ethnicity had been randomly assigned to and tested by each experimenter.

Once in the laboratory, participants were told that the investigators wanted to learn about subjective and physiological responses to painful procedures, as well as how family and personality factors may be related to these responses. Participants were informed that the study examined how individuals respond to a standardized experimental pain procedure, the cold pressor task (submerging a hand in ice cold water), designed to simulate the sensations brought on by a painful medical procedure. Participants were apprised of their freedom to remove their hands from the cold water at any time during the task or withdraw from the experiment at any time without prejudice. If the participant continued to express an interest in participating, written consent was obtained.

After providing consent, each participant completed one 45-minute session. First, participants completed the following paper and pencil questionnaires: The Family Health Questionnaire (Koutanji, Pearce, & Oakley, 1998), which assesses personal and family health, and the Bem Sex Role Inventory (Bem, 1974), which assesses identification with traditional stereotyped gender roles. Second, participants donned a heart rate monitor consisting of noninvasive chest and wrist bands. Third, participants received verbal instructions for the cold pressor task. These instructions included requests to sit upright with limbs uncrossed and feet flat on the floor and to remain silent during the painful procedure. These instructions were presented in the context of "minimizing the effects of extraneous variables on heart rate".

The cold pressor task consisted of the following sequence of events: (a) Audio Cue 1: cue for start of 60 second baseline phase, (b) Baseline Phase: the participant sat quietly for 60 seconds to obtain baseline measurements, (c) Audio Cue 2: cue for participant to immerse his or her hand in the cold water, (d) Pain Phase: painful stimulation until the participant removed his or her hand from the cold pressor or 180 seconds were completed, whichever came first, (e) Audio Cue 3: cue for participant to withdraw from the cold water, if they had not already done so.

After explaining the procedure, the experimenter informed participants as to where the experimenter would be positioned (social context) during the cold pressor task. Dependent on the condition to which the participant was assigned, the experimenter made one of the following statements: (a) "While you are doing the cold pressor task, I will be standing just outside this door. After removing your hand from the cold pressor and drying your hand with the towel provided, open the door to let me know you are done." (experimenter absent condition), (b) "This thing right here (*experimenter points to an opaque glass window with curtains opened*) is a one-way mirror. While you are doing the cold pressor task, I will be looking through it. I will come back into this room when you are done." (experimenter observing unseen condition), or (c) "While you are doing the cold pressor task, I will be right here in the room." (experimenter present condition).

Participants' facial displays during the cold pressor task were surreptitiously recorded using a concealed video camera. Following the cold pressor task, participants rated their pain using the following paper and pencil measures: (a) Visual Analog Scale, (b) Verbal Rating Scales (sensory intensity and affective unpleasantness) and (c) the short-form McGill Pain Questionnaire. The scales were administered consecutively and in the same order for all groups. Subsequently, participants completed the Self-Monitoring Scale, a paper and pencil measure to assess the individual differences in the tendency to use forms of social impression management tactics. Next, experimenters conducted a semi-structured interview to assess participants' suspicions regarding the experimental manipulations. Participants provided numerical ratings of suspiciousness on a scale of 0 (not suspicious) to 100 (extremely suspicious) for overall suspiciousness (suspiciousness as to whether the study actually was as it was presented), suspiciousness of being videotaped, and suspiciousness of being watched. They also responded to open-ended questions about *why* they were suspicious, *when* they first noticed feeling suspicious, and *how* their suspicions may have influenced their experience or expression.

Finally, experimenters conducted a thorough verbal debriefing and second consent process. The experimenter described the full purpose of the study, rationale and methods, including the collection of video data, and reasons for using deception. Participants were informed that if they did not want their facial display analyzed, the videotape would be erased in their presence, and they would receive the same compensation for their time. Participants were invited to express any concerns they had with the use of deception or other procedures. (Note: No participants reported the level of deception used in the present study to be unreasonable or harmful.) Following full disclosure during the debriefing, written consent was obtained for the use of the recordings of participants' facial displays for scientific purposes. Upon providing consent, participants were invited to call the lab any time within one year to withdraw consent for use of their videotape and/or other study data should they change their mind at a later date

(Note: All participants provided written consent for analysis of their videotape. No participants withdrew consent at the time or during the year following completion of data collection). Participants were provided with contact information for the primary investigator, co-investigators and the UBC Office of Research Services, as well as copies of both consent forms (initial and post-debriefing) and a written debriefing. Volunteers received a bonus percent toward their course grade for their participation.

RESULTS

Overview

The findings are organized as follows: First, methods used to prepare data for analyses are described. Second, descriptive statistics regarding age and ethnicity of participants are presented. Third, effects of experimenter audience conditions on nonverbal pain responses (facial expression, cold immersion time, heart rate) during pain stimulation are reported. Fourth, participants' retrospective verbal self-reports of the pain experience are detailed. Fifth, judges' global ratings of pain after viewing videoclips of participants are reported. Sixth, discrepancies between self-reports and judges' pain ratings as a function of experimenter audience condition are explored. Seventh, a regression model is presented examining whether experimenter audience condition would account for unique variance in the display of a mild pain expression prototype even after controlling for variance accounted for by self-report pain ratings, cold immersion time, heart rate, suspiciousness, self-monitoring, participant sex, experimenter sex and visible minority status. Finally, participants' retrospective reports of suspiciousness about the experimental method are described.

Data Cleaning and Screening

Prior to analysis, dependent variable data were examined for accuracy of data entry, missing values, and the fit of distributions with assumptions of the statistical tests employed.

First, univariate descriptive statistics were inspected for accuracy of input by examining a) out-of-range values, b) plausible means and standard deviations, and c) univariate outliers.

Next, missing data were evaluated, taking into consideration the number and distribution of missing values. No self-reported pain Visual Analog Scale or Verbal Rating Scale data were missing. Some omissions were noted in completion of the Self-monitoring Scale (i.e., three of

120 subjects did not provide an answer on one of 25 questions). No pattern to the missing data was apparent on visual inspection. To test whether data were missing at random, a dummy variable was formed for each variable with missing data to indicate the presence or absence of missing data. Next, correlational analyses were performed with the dummy variables. No significant relationships or patterns of missing data were observed. Missing data were judged to be non-problematic and due to random clerical omissions in completing questionnaire data. Accordingly, missing data were dealt with using a traditional mean imputation method. Specifically, the sample mean answer (across audience conditions) was entered in place of the missing value (Tabachnick & Fidell, 2001).

Next, the data were examined to establish fit with assumptions required for each statistical test performed. If an assumption was violated, a transformation was applied or an alternate statistical procedure was used.

When evaluating the magnitudes of correlations between variables, Cohen's (1988) guidelines for the interpretation of correlations in psychological research were applied. Specifically, positive or negative statistically significant correlation coefficients with an absolute magnitude of .50 or greater were described as "large", correlation coefficients with an absolute magnitude between .30 and .50 were described as "medium", and correlation coefficients with an absolute magnitude between .10 and .30 were described as "small" (Cohen, 1988).

Finally, experimenter randomization checks were conducted. Each experimenter tested an equal number of participants in each audience condition to balance potential effects of individual experimenters across groups. However, because the experimenters constituted an important part of the experimental manipulation, statistical analyses were conducted to determine whether experimenters' individual effects on dependent measures were equivalent. For these manipulation checks, the independent variable was experimenter, with four levels (experimenter 1, experimenter 2, experimenter 3 and experimenter 4). The dependent variables examined comprised scores on expressive pain behaviour measures. A series of One Way Between-Groups ANOVAs was conducted with alpha set at .05 per test to ensure that any potential problems with the experimenter manipulation were identified. The model assumed random effects. The individual experimenter did not reliably affect the dependent variables examined ($p > .05$ in all cases). Accordingly, the variable "experimenter" was not used as a covariate for the main analyses.

Participant Demographics

Age

The convenience sample comprised 60 women and 60 men between the ages of 18 and 25 years ($M = 19.70$, $SD = 1.49$). A univariate (audience condition: experimenter absent versus experimenter observing unseen versus experimenter present) between-groups Analysis of Variance (ANOVA) examined group differences in participant age. Results revealed no significant main effects of audience condition, F (2, 117) = .02. p = .97, Partial $\eta^2 = 0$. Ages of participants in the experimenter absent group ($M = 19.75$ years, $SD = 1.77$), experimenter observing unseen group ($M = 19.67$ years, $SD = 1.28$) and the experimenter present group ($M = 19.70$ years, $SD = 1.41$) did not differ reliably. Because the sample was relatively homogeneous with respect to age, no differences in age between audience groups were observed, and no specific age-related hypotheses were considered, age was not considered further as a moderator variable.

Ethnicity

The sample was diversified in self-reported cultural mix and visible ethnic background. Participants' responses to an open-ended question asking them to self-identify ethnicity yielded twenty-five different response categories. Recategorization of responses into the sixteen ethnic origin categories used by Statistics Canada in the 2001 Census resulted in the following endorsements listed from most popular to least popular responses: East/South Asian Origins (Chinese, Filipino, Vietnamese, Japanese, Korean) = 47.5%, Other Origins (American, Canadian, Quebecois) = 36.6%, South Asian Origins (Pakistani, Punjabi, Sri Lankan, East Indian, South Asian) = 6.6%, Southern European Origins (Balkan (Croatian, Serbian, Yugoslav), Greek, Italian, Portuguese, Spanish) = 2.5%, Eastern European Origins (Czech, Slovak, Hungarian (Magyar), Polish, Romanian, Russian, Ukrainian) = 1.6%, West Asian Origins (Armenian, Iranian) = 1.6%, African Origins (African (Black)) = .8%, Aboriginal Origins (Inuit, Métis, North American Indian) = .8%, British Origins (English, Irish, Scottish, Welsh) = .8%. Participants' responses were also categorized using the twelve ethnicity categories used in the UBC 1997 Undergraduate Student Demographic Survey. The most commonly described ethnicities in the study sample using these criteria were white (40.8%), Chinese (36.6%) and South Asian (8.3%), and these represented the majority of the sample (85.7%). These data were in line with the UBC 1997 Undergraduate Student Demographic Survey, which also identified white (49.0%), Chinese (31.0%) and South Asian (4.9%) as the three most commonly endorsed ethnicities.

Participants' self-identified ethnicities were further collapsed into two groups based on the Statistics Canada 2001 Census distinction between "visible minority populations" (Chinese, South Asian, Black, Filipino, Latin American, Southeast Asian, Arab, West Asian, Korean, Japanese, Other Pacific Islanders, Multiple visible minority) and "all others" (white, aboriginal). It is of note that all seven individuals who self-identified their ethnicity as "Canadian" were other-identified as "white" by two independent raters (100% agreement) who viewed the videotapes. Data from these seven participants were included in the *Not* Visible minority category for purposes of statistical analysis. Classifications of visible minority status based on self-reported ethnicity provided by the other 113 participants were consistent with the observer-rated ethnicity of two independent raters (100% agreement). Fifty-eight percent of participants were classified as coming from visible minority populations. This figure reflects datum indicating that forty-eight percent of UBC students considered themselves part of a visible minority group (UBC 1997 Undergraduate Student Demographic Survey).

The visible minority status data also reflects the similarity of participant-experimenter dyads. Each dyad was coded as "similar" or "dissimilar" in visible minority status based on participant and experimenter self-descriptions and observer judgments. All experimenters were Caucasian (no visible minority status), so the fifty participants identified as "white" or "Caucasian" (no visible minority status) (n = 17 in the experimenter absent group, n = 15 in the experimenter observing unseen group and n = 18 in the experimenter present group) were tested by an experimenter who was similar with respect to this ethnic grouping. In contrast, the seventy participants identified as having visible minority status (n = 23 in the experimenter absent group, n = 25 in the experimenter observing unseen group, and n = 22 in the experimenter present group) were tested by an experimenter who was dissimilar in ethnic grouping. A Pearson Chi-Square analysis was conducted to determine whether any of the audience groups were more or less likely to be matched with respect to similarity of participant-experimenter visible minority status identification. No statistically significant differences were observed, χ^2 (2, N = 120) = .48, *p* = .78. Although participant and experimenter ethnicity were not matched explicitly as part of the experimental method, these results demonstrate that randomization procedures led to balanced proportions of participants from each ethnicity tested by each experimenter in each group. For exploratory purposes, experimenter-participant visible minority status similarity was included as a predictor in the logistic regression analysis on facial expression during pain.

Pain Stimulus Manipulation Check

Data from the Short Form-McGill Pain Questionnaire (SF-MPQ; Melzack, 1987) confirmed that the cold pressor provoked an experience qualitatively similar to pain described by patients with painful conditions. Of 120 participants, more than seventy-five percent of the participants described the pain as sharp (*n* = 104), aching (*n* = 93), and throbbing (*n* = 93). More than fifty percent of participants described the pain as stabbing (*n* = 81), hot–burning (*n* = 78), shooting (*n* = 77), punishing (*n* = 71), heavy (*n* = 71), cramping (*n* = 68), splitting (*n* = 68), and gnawing (*n* = 64). Fewer than fifty percent of the participants described the pain as exhausting (*n* = 56), fearful (*n* = 53), tender (*n* = 40) and sickening (*n* = 34). Participants' ratings for the fifteen SF-MPQ pain quality adjectives rated on a four point numerical scale (0 = none, 1 = mild, 2 = moderate and 3 = severe) were summed to form the total pain rating index (T-PRI) scores. The mean SF-MPQ T-PRI score (scale 0 to 45) across conditions was 22.97 (*SD* = 8.10). The total mean score observed was similar to SF-MPQ T-PRI scores associated with acute pain conditions, such as post-surgical pain, mucositis, angioplasty, and sheath removal, as well as chronic pain conditions, such as musculoskeletal pain, arthritis, osteoarthritis, rheumatoid arthritis, and chronic cancer pain (*p*. 47, Turk & Melzack, 2001), confirming that the cold pressor produced clinically relevant pain quality.

Observational Measures

Facial Expression

Changes in facial expression during pain as a function of audience condition were examined in detail using FACS data. Analyses focused on variables that fall under one of three main categories: (1) empirically supported pain face prototypes, (2) empirically supported emotion face prototypes for sadness, fear, anger, disgust, surprise and happiness, and (3) relevant action units not included in empirically supported prototypes (see method section for inclusion criteria).

Empirically Supported Pain Face Prototypes

FACS coding reliability.

First, the pain BOEL facial actions were examined to ensure reliable coding. Inter-rater scoring reliability was calculated using the formula recommended by the creators of the FACS measure (Ekman & Friesen, 1978). The proportion of agreement on actions recorded by two coders was calculated relative to the total number of actions coded as occurring by each of the coders (Ekman & Friesen, 1978). For the BOEL data, coders met the pre-set standard of > 75% frequency coding reliability for each facial action (Brow lowering = 76%, Orbital tightening = 84%, Eyes close = 83%, Levator contraction = 91%). The average reliability for BOEL facial actions scored was 87.89%.

Percent occurrence descriptive statistics.

Percent occurrence scores for each of the component BOEL facial actions and Williams' (2002) pain face prototype (co-occurrence of BOEL facial actions) were calculated. Out of all recorded occasions that a facial action could be coded (100%), Brow lowering (AU 4) occurred 4.68% of the time it could be observed during pain compared to .25% of the time during baseline

(4.43 % mean difference), Orbital tightening (AU 6-7) occurred 4.61 % of the time it could be observed during pain compared to .75 % of the time during baseline (3.86% mean difference), Eyes close (AU 43) occurred 7.02 % of the time it could be observed during pain compared to 3.41 % of the time during baseline (3.61% mean difference), and Levator contraction (AU 9-10) occurred 2.52 % of the time it could be observed during pain compared to .08 % of the time during baseline (1.7% mean difference). Paired samples *t*-tests with alpha set at .05 / 4 = .0125 confirmed that each of the BOEL facial actions occurred significantly more often during the cold pressor pain stimulus (pain phase) than before the cold pressor (baseline phase) (see Table 6). Percentages indicating the weighted display time of the pain face prototype (AU 4 and AU 6-7 and AU 43 and AU 9-10) before the cold pressor task (baseline) and during the cold pressor task (pain) were calculated. Overall, display times were longer during the cold pressor task (M = 1.27, SD = 6.03) compared to baseline (M = 0, SD = 0), (t (119) = -2.31, p = .02.

Initially, a 3 between-Groups (audience condition: experimenter absent group versus experimenter observing group unseen versus experimenter present group) X 2 within-subjects (time: baseline phase versus pain phase) mixed ANOVA was planned to examine whether these variables influenced the pain prototype facial expression time. However, examination of the descriptive statistics revealed that the prototypical pain face was not observed at all during the baseline phase (M = 0 and SD = 0 for all groups) and was only observed in one of three audience conditions. Descriptive statistics are reported in Table 7 and Table 8.

Table 6

Percent Occurrence of BOEL Facial Actions during Baseline and Pain

Facial Actions and Prototypes	Baseline *M (SD)*	Pain *M (SD)*	Paired samples *t*	*df*	*p*
Brow Lowerer (4)	.25 (1.56)	4.68 (12.07)	-4.31	119	<.001
Orbital Tightening (6 or 7)	.75 (3.92)	4.61 (11.23)	-3.70	119	<.001
Eyes Close (43)	3.41 (14.17)	7.02 (18.07)	-2.93	119	.004
Levator Contraction (9 or 10)	.08 (.91)	2.52 (7.69)	-3.50	119	<.001
Moderate Pain Prototype (4 + (6 or 7) + 43 + (9 or 10))	0 (0)	1.27 (6.03)	-2.31	119	.022
Mild Pain Prototype (4 + (6, 7 or 43))	0 (0)	5.83 (17.09)	-3.73	119	<.001

Note. Scale 0 to 100% of the time.

Moderate pain prototype (cooccurrence of AU 4, AU 6-7, AU 43, and AU 9-10).

During the cold pressor task, the prototypical pain face was observed occasionally in the experimenter absent group (*M* = 3.33, *SD* = 9.72) but unobserved in the experimenter observing unseen group and the experimenter present group. These means were considerably lower than expected. Examination of frequency data for the number of participants in each group who displayed the prototypical pain face as operationally defined revealed that only 6.66% of participants displayed the prototypical pain face during the observation periods. While this approach was specific (*Specificity* = (True Negatives) / (True Negatives + False Positives) = 120 / (120 + 0) = 1) it was not sensitive (*Sensitivity* = (True Positives) / (True Positives + False

Negatives) = 6 / (6 + 114) = .05) for this sample and pain stimulus. Given the unexpectedly low sensitivity of the pain face measure, an ANOVA was no longer considered an appropriate statistical procedure to examine group differences. The data were markedly skewed and did not have the same variance in each category of the between groups independent variable (audience condition). As well, given the low number of participants who displayed the pain face, the sample size was no longer considered sufficient.

Consideration of other approaches to measuring facial expression of pain.

Alternative facial expression measurement strategies were considered. Previous researchers have used summary approaches that do not require contiguous display or overlap of more than one variable, but, to date, no single approach or index has been adopted widely. The summary approaches vary in the number of AUs used as components and whether they take frequency and intensity into account. Approaches taken include summing the intensity scores for brow lowering, orbital tightening, levator contraction, mouth opening, and eye closure (Prkachin, 2005), summing the products of intensity scores by duration scores for brow lowering, orbital tightening, levator contraction, and eye closure (Prkachin et al, 2004), transforming intensity scores for each action to standard scores, multiplying scores by their PCA factor-score coefficients and then summing scores (Prkachin, 1992) or requiring the display of one of brow lowering, orbital tightening and upper lip raising coded three or higher with respect to intensity (Botvinick, Jha, Bylsma, Fabian, Solomon, & Prkachin, 2005). Summary approaches or approaches requiring only one facial action associated with pain are less specific than approaches requiring cooccurrence of more than one facial action.

Adopting a summary approach of Prkachin’s (1992) four core pain facial actions or an individual AU criterion of these actions led to the percentage of participants displaying facial evidence of pain increase from 0% to 15% during baseline and from 6.66% to 54.16% during the cold pressor. In the experimenter absent group, at least one pain-related facial action was displayed by 3.33% of participants during baseline and 25.83% of participants during pain. In the experimenter observing unseen group, at least one pain-related facial action was displayed by 5.83% of participants during baseline and 15% of participants during pain. In the experimenter present group, at least one pain-related facial action was displayed by 5.83% of participants during baseline and 13.33% of participants during pain. Such an approach would be more sensitive and less specific than a prototype approach requiring the cooccurrence of all four core actions. In the present study, summary approaches that did not require contiguity of more than one facial action led to false-positive categorizations (e.g., pain face coded during baseline) in 15% of participants. Moreover, with the exception of eyes close (AU 43) all other pain-related AUs are associated with at least one emotion prototype. Consequently, examining scores that could be based on a single facial action poses problems for interpretation. As well, pain-related facial actions appear more closely together in time during genuine pain compared to faked pain where people exhibit the component facial actions in a sequential manner (Hill & Craig, 2002). Finally, we hoped to make a unique contribution to the pain literature by examining data using a parallel approach to that used in the facial expression of emotion literature, which generally requires cooccurrence of more than one facial action as a criterion for observance of emotion face prototypes (exceptions are disgust faces and false smiles).

Accordingly, rather than using a summary score or requiring only one facial action associated with pain, we refined our operational criteria for a prototypical pain expression. Two other prototypes have been examined in the literature. In one study, LeResche (1982) identified a prototype consisting of the simultaneous occurrence of 4 AND (6 or 7 or 11) AND 20 AND (25 or 26 or 27) AND 43, based on examination of sixteen candid photographs showing faces of individuals in situations associated with severe, intense acute pain such as surgery without anesthesia. Exploration of the use of this prototype revealed that even fewer instances of this prototype would be observed. Given that the cold pressor elicits a more moderate level of pain, is experimental and is generally considered non-threatening, it is not surprising that this more intense display was not commonly observed. In later studies, LeResche and colleagues (1988; 1992) revised their operational definition of a pain face prototype as the simultaneous occurrence of (6 or 7) AND (4 or 43 or 45) in patients with temporomandibular disorder. Based on the evidence gathered since that time and the possible inflation of scoring of prototypes based on LeResche and colleague's inclusion of AU 45 (blink) as a potential one of two necessary components, we chose a slightly different configuration of action units: 4 AND (6 or 7 or 43). The new operational definition required co-occurrence of a subset of the BOEL facial actions, brow lowering and eye orbit closing. This conceptualization is heretofore referred to as the mild pain prototype face. The facial actions chosen show the most stable relation to pain in empirical studies (Prkachin & Mercer, 1989). As well, Brow lowering and eye orbit closing also appear to be the first actions recruited in displays of pain. According to the Sequential Model of Pain Expression (Prkachin & Mercer, 1989), brow lowering (AU 4) and eye orbit closing (AU 7 then AU 6 then AU 43) are the first actions displayed during pain. These upper face actions are followed by middle facial actions (upper lip raise (AU 10) then nose wrinkling (AU 9)). The middle face actions are followed by lower face actions (mouth opening then horizontal stretching of the lips).

Prkachin and Mercer's (1989) sequential model of pain expression proposes that recruitment of the actions in the different phases depends on the severity and duration of the experience. Accordingly, the observation of the upper face actions only may be more likely during relatively mild pain, with the addition of middle face actions more likely during moderate pain and lower face actions more likely during severe pain, with all also dependent on the duration of the noxious event. Based on this model, the mild to moderate severity of pain produced by the cold pressor and relatively short duration of the cold pressor task may have resulted in pain expressions, when observed, that were more reflective of the first phase of the Sequential Model of Pain Expression.

Mild pain prototype ((AU 4 AND (AU 6-7 OR AU 43)).

Examination of the descriptive statistics revealed that the mild pain face was not observed during the baseline phase (M = 0 and SD = 0 for all groups). Accordingly, it was unnecessary to include baseline display as a covariate or time phase as a repeated measures factor in the ANOVA. Instead, the mild pain prototype display dependent variable can be interpreted as a difference score (occurrence during cold pressor minus occurrence during baseline) with the zero incidence of display occurrence during baseline leaving the cold pressor display scores unchanged.

Assumptions of a Fixed-Effects ANOVA with equal n's were examined. The assumption of homogeneity of variances was violated. However, ANOVA is robust to moderate departures from homogeneity of variance (Box, 1954). A rule of thumb is that the ratio of largest to smallest group variances should be 4:1 or less (Moore, 1995) and the ratio for these data was 3.9:1. The assumption of normality was also violated. A Kolmogorov-Smirnov Goodness of Fit Test indicated that the distribution of cold immersion times deviated significantly from a standard normal distribution [Z (120) = 4.56, $p < .001$]. The data were positively skewed (*Fisher's skew* = 3.83, SE = .22), which indicated that the bulk of participants tended to display the mild pain prototype face for short periods of time or not all. In a Fixed Effects ANOVA with equal *n*'s, the consequences of violation of assumptions of normality with respect to skewness appear to have very little effect on either the level of significance or the power (Glass & Hopkins, 1996). If there are at least 20 degrees of freedom for error in a univariate ANOVA, the *F* test is said to be robust to violations of normality of variables (Tabachnick & Fidell, 2001), and 117 degrees of freedom for error are available in this univariate ANOVA.

A 3 (audience condition: absent versus observing unseen versus present) X 2 (experimenter sex: male versus female) X 2 (participant sex: male versus female) ANOVA was conducted. Audience condition significantly influenced the percentage of time participants' displayed the mild pain face prototype during the cold pressor task, F (2, 108) = 4.30, p = .01, Partial $\eta 2$ = .07. No reliable main effects of experimenter sex (F (1, 108) = .25, p = .61, Partial $\eta 2 < .01$) or participant sex (F (1, 108) = .87, p = .35, Partial $\eta 2 < .01$) were observed. No reliable two way or three way interactions between audience condition, experimenter sex and/or participant sex were observed ($p > .10$). The lack of significant interactions indicates that neither experimenter sex nor participant sex were moderators of the relationship between audience condition and facial expression during pain.

Tukey post hoc tests revealed that the experimenter absent group (M = 12.00, SD = 24.99) displayed the mild pain prototype more often than the experimenter present group (M = 1.25, SD = 6.39), p = .01. The experimenter observing unseen group (M = 4.25, SD = 12.74) did not reliably differ from the experimenter absent group (p = .09) or the experimenter present group (p = .69).

Although the univariate ANOVA was considered robust to assumption violations, the distribution of data indicated that it might be more appropriate to examine the display of the mild pain prototype as a dichotomous variable (display versus no display). Because the mild pain prototype was not displayed at all during baseline, no analysis of these data was required.

A Pearson Chi-Square analysis was conducted to determine whether the experimenter absent group versus the experimenter observing unseen group versus the experimenter present group were more or less likely to display the mild pain face prototype. The results of the test were reliable, χ^2 (2, N = 120) = 13.06, p = .001. Separate 2 X 2 contingency tables were formed to elucidate which groups differed. The experimenter absent group was more likely to display the mild pain face prototype (40%) than the experimenter observing unseen group (17.5%), χ^2 (1, N = 80) = 4.94, p = .02, or the experimenter present group (7.5%), χ^2 (1, N = 80) = 11.66, p = .001. The likelihood of mild pain face prototype display in the experimenter observing unseen group did not reliably differ from the experimenter present group, χ^2 (1, N = 80) = 1.82, p = .17. Of particular note is the relatively low likelihood of any of the groups displaying the mild pain face prototype (21.7%) compared to no display (78.3%).

Table 7

Means (and Standard Deviations) of Pain BOEL Facial Action Percent Occurrence as a Function of Audience Condition and Time

Facial Actions and Prototypes	Experimenter Audience Condition					
	Absent[a]		Unseen[a]		Present[a]	
	Baseline	Pain	Baseline	Pain	Baseline	Pain
Brow Lowerer	.25	8.58	.50	4.54	0	.91
	(1.58)	(16.38)	(2.20)	(11.65)	(0)	(3.20)
Orbital Tightening	0	8.75	0	2.16	2.25	2.91
	(0)	(15.40)	(0)	(6.01)	(6.59)	(9.21)
Eyes Close	5.00	12.50	3.00	2.75	2.25	5.83
	(20.12)	(20.91)	(10.17)	(14.77)	(9.99)	(17.02)
Levator	0	6.58	.25	1.83	0	.16
Contraction	(0)	(12.03)	(1.58)	(4.33)	(0)	(1.05)
Moderate Pain	0	3.33	0	0	0	.50
Prototype	(0)	(9.72)	(0)	(0)	(0)	(3.16)
Mild Pain	0	12.00	0	4.25	0	1.25
Prototype	(0)	(24.99)	(0)	(12.74)	(0)	(6.39)

Note. Scale: 0-100% of the observation phase.

[a]$n = 40$

Table 8

Number of Participants Who Displayed Facial Action or Prototype as a Function of Audience Condition and Time

Facial Actions and Prototypes	Audience Condition					
	Absent[a]		Unseen[a]		Present[a]	
	Baseline	Pain	Baseline	Pain	Baseline	Pain
Brow Lowerer	1	19	2	12	0	4
Orbital Tightening	0	21	0	7	5	7
Eyes Close	3	20	5	4	2	7
Levator Contraction	0	13	1	9	5	1
Any of Prototype AUs 4, 6, 7, 9, 10, 43	4	31	7	18	7	16
Any of Prototype + Variant AUs 4, 6, 7, 9, 10, 12, 25, 26, 27, 43	20	33	23	36	21	33
Moderate Pain Prototype 4 + 6,7 + 43 + 9,10	0	7	0	0	0	1
Mild Pain Prototype 4 + 6,7,43	0	16	0	7	0	3

[a]*n* = 40

Empirically Supported Emotion Face Prototypes for Sadness, Fear, Anger, Disgust, Surprise and Happiness

FACS coding reliability.

The component facial actions that comprise each empirically supported emotion prototype were examined to ensure reliable coding. Inter-rater scoring reliability met the pre-set standard of > 75% frequency coding reliability for each facial action (see Table 9).

Table 9

Facial Action Coding System Reliability for Components of Emotion Prototypes

AU #	AU Description	% Coding Reliability
1	Inner brow raiser	95
2	Outer brow raiser	95
4	Brow lowerer	76
5	Upper lid raiser	90
6	Cheek raiser	84
7	Lid tighten	84
9	Nose wrinkler	91
10	Upper lip raiser	91
12	Lip corner puller	87
15	Lip corner depressor	100
17	Chin raiser	100
23	Lip tightener	78
25/26/27	Lips part/mouth open	88

Percent occurrence descriptive statistics.

Means and standard deviations for the occurrence of facial expressions prototypically associated with disgust, fear, anger, sadness and surprise appear in Table 10. The number of participants who showed various displays appears in Table 11.

Fear, anger, sadness, and surprise. Using the operational definitions provided in the methods section and The Investigator's Guide to FACS (Ekman, Friesen & Hagar, 2002), no prototypical facial expressions were observed for anger or sadness during baseline or pain phases. Prototypical facial expressions associated with fear and surprise were rarely observed. Fear displays were not observed during baseline (M = 0% of the time, SD = 0) and rarely observed during the pain phase (M = .02% of the time, SD = .30). Fear displays were observed in one participant during the pain phase. Surprise displays were rarely observed during baseline (.08% of the time, SD = .91) and the pain phase (.19% of the time, SD = 1.16). Surprise displays were observed in one participant during baseline and four participants during the pain phase. Because fewer than five percent of the participants displayed prototypical facial expressions of fear, anger, sadness and surprise as operationally defined, these variables were not examined further.

Disgust. The disgust prototypes described in The Investigator's Guide to FACS (Ekman, Friesen & Hagar, 2002) varied from requiring only a single action unit (AU 9 or AU 10) to requiring cooccurrence of a number of facial actions. If the minimum criterion of one action unit is required (prototypes: 9 OR 10), the number of disgust displays increased. Disgust displays were observed during baseline (M = .08, SD = .91) and observed during the pain phase (M = 2.74, SD = 8.5). Disgust displays were observed in six participants during baseline and twentythree participants during the pain phase. Because disgust expressions were observed in more than 5% of the subjects, these expressions were examined further.

A 2 within-subjects (time) X 3 between-groups (audience condition) mixed ANOVA was conducted to examine whether these variables influenced the occurrence of disgust expressions (minimum criteria) [(AU 9 ≠ 0) OR (AU 10 ≠ 0)].

A reliable within-subjects main effect of time was observed [F (1, 117) = 13.29, $p < .001$, Partial η2 = .10], with fewer disgust displays observed during baseline (M = .08, SD = .91) than during the cold pressor (M = 2.74, SD = 8.25). As well, a reliable between-subjects main effect of audience condition on occurrence of disgust expressions was observed [F (2, 117) = 5.81, p = .004, Partial η2 = .09]. Tukey post hoc tests indicated that, across time periods, disgust expressions were observed more frequently in the experimenter absent group (M = 3.08) than the experimenter present group (M = .11, p = .003). The experimenter absent group did not reliably differ from the experimenter observing unseen group (M = 1.04, p = .06). The experimenter observing unseen group did not differ reliably from the experiment present group (p = .55). These main effects must be interpreted in the context of a significant interaction.

A reliable interaction between the factors was also observed, F (2, 117) = 6.04, p = .003, Partial η2 = .09. A priori it was decided that a significant interaction would be broken down by holding time constant as the differences among audience conditions were of the most interest. Simple Main Effects (with an adjusted error term) revealed no reliable differences between groups during the baseline phase [F (2, 117) = 1.0, p = .37, Partial η2 = .01]. However, simple main effects (with an adjusted error term) revealed reliable differences between groups during the pain phase [F (2, 117) = 5.99, p = .003, Partial η2 = .09]. During the pain phase, disgust expressions were shown more often when the experimenter was absent (M = 6.58, SD = 12.03) than when the experimenter was observing unseen (*M* = 1.83, *SD* = 4.33), $p = .04$ or when the experimenter was present (*M* = .16, *SD* = 1.05), $p = .003$. No differences were observed between the latter two groups, $p = .64$.

Happiness. Facial expressions associated with the emotion prototype happiness (operationalized as "felt smiles") were observed during baseline and pain.

a) Felt smiles.

Felt smiles were observed during baseline (.41% of the time, *SD* = 3.01) and during pain (2.08% of the time, *SD* = 8.34). Felt smiles were displayed by three participants during baseline and fifteen participants during pain.

A 2 within-subjects (time) X 3 between-groups (audience condition) mixed ANOVA was conducted to examine whether these variables influenced the occurrence of felt smiles (AU 12 and AU 6). No significant interaction between the factors was observed, $F(2, 117) = 2.18$, $p = .12$, Partial $\eta 2 = .03$. A reliable within-subjects main effect of time was observed [$F(1, 117) = 4.98$, $p = .02$, Partial $\eta 2 = .041$], with fewer felt smiles observed during baseline (*M* = .41, *SD* = 3.01) than during the cold pressor (*M* = 2.08, *SD* = 8.34). As well, a reliable between-subjects main effect of audience condition on occurrence of felt smiles was observed [$F(2, 117) = 5.24$, $p = .007$, Partial $\eta 2 = .08$]. Tukey post hoc tests indicated that, across time periods, felt smiles were observed more frequently in the experimenter present group (*M* = 3.12) than the experimenter absent group (*M* = 0, $p = .008$) or the experimenter observing unseen group (*M* = .62, $p = .04$). The latter two groups did not reliably differ from each other ($p = .81$).

b) False smiles.

False smiles [(AU 12 > 3) AND (AU 6 = 0)] were observed during baseline (2.41% of the time, *SD* = 8.88) and pain (1.63% of the time, *SD* = 5.46). False smiles were displayed by 12 participants during baseline and 16 participants during pain.

A 2 within-subjects (time) X 3 between-groups (audience condition) mixed ANOVA was conducted to examine whether these variables influenced the occurrence of false smiles. No significant within-subjects main effects of time [F (1, 117) = .75, p = .38, Partial η2 = .006] or audience condition [F (2, 117) = 1.44, p = .24, Partial η2 = .024] were observed. However, there was a significant audience condition X time interaction [F (2, 117) = 3.12, p = .04, Partial η2 = .051).

A priori it was decided that a significant interaction would be broken down by holding time constant as differences among audience conditions were of greater interest. Simple Main Effects (with an adjusted error term) revealed no reliable differences between groups during the baseline phase [F (2, 117) = 2.27, p = .107, Partial η2 = .037) or the pain phase [F (2, 117) = 2.00, p = .139, Partial η2 = .033).

c) Miserable smiles.

Miserable smiles were not observed at all during baseline and were observed approximately 1% of the time during pain. Miserable smiles were not observed during baseline. Miserable smiles were observed in five participants during the cold pressor. Because fewer than five percent of participants displayed miserable smiles during the observation periods, miserable smiles were not subjected to further statistical analysis.

Figure 3. Occurrence of pain and emotion facial expression prototypes during the cold pressor task as a function of audience condition.

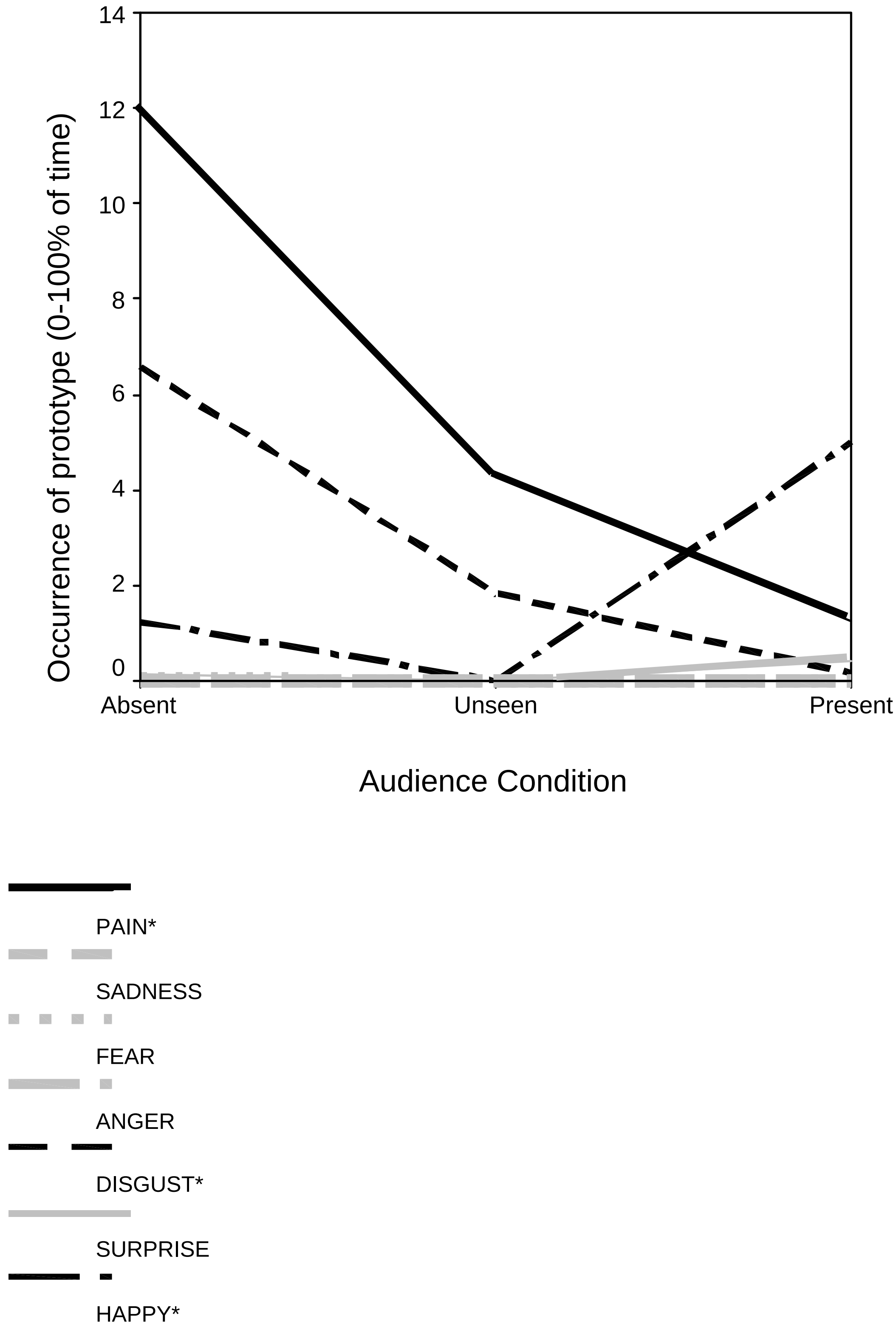


Table 10

Means (and Standard Deviations) of Percent Occurrence of Prototypical Pain and Emotion Facial Expressions Before and During the Cold Pressor as a Function of Audience Condition

Prototype	Experimenter Audience Condition					
(Scale: 0-100%)	Absent[a]		Unseen[a]		Present[a]	
	Baseline	Pain	Baseline	Pain	Baseline	Pain
Moderate Pain	0	3.33	0	0	0	.50
	(0)	(9.72)	(0)	(0)	(0)	(3.16)
Mild Pain	0	12.00	0	4.25	0	1.25
	(0)	(24.99)	(0)	(12.74)	(0)	(6.39)
Sadness	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)
Fear	0	.08	0	0	0	0
	(0)	(.52)	(0)	(0)	(0)	(0)
Anger	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)
Disgust	0	6.58	.25	1.83	0	.16
	(0)	(12.03)	(1.58)	(4.33)	(0)	(1.05)
Surprise	0	.16	0	0	.25	.41
	(0)	(.73)	(0)	(0)	(1.58)	(1.87)
Happiness	0	1.25	0	0	1.25	5.00
(Felt Smile)	(0)	(3.34)	(0)	(0)	(5.15)	(13.69)

Note. Scale: 0-100% of the time during the observation phase. [a]$n = 40$

Table 11

Number of Participants Who Displayed Prototypical Pain and Emotion Facial Expressions Before and During the Cold Pressor as a Function of Audience Condition

Prototype	Experimenter Audience Condition					
	Absent[a]		Observing Unseen[a]		Present[a]	
	Baseline	Pain	Baseline	Pain	Baseline	Pain
Moderate Pain	0	7	0	0	0	1
Mild Pain	0	18	0	5	0	2
Sadness	0	0	0	0	0	0
Fear	0	1	0	0	0	0
Anger	0	0	0	0	0	0
Disgust	0	13	1	9	5	1
Surprise	0	2	0	0	1	2
Happiness (Felt Smile)	0	7	0	0	3	8

[a] *n = 40*

Relevant Action Units Not Included in Empirically Supported Prototypes

After examining the reliability and relevance of the BOEL facial actions, data were examined to determine whether any of the FACS-coded actions that met the following inclusion criteria: (1) facial actions not included in any of the pain or emotion prototypes examined, (2) minimum 70% coding reliability, (3) minimum 5% occurrence, (4) associated with pain in previous research and (5) display frequency during baseline phase differed reliably from display during the pain phase. No facial actions additional to those examined as part of the pain and emotion prototypes that met these criteria. Although AU 45 Blink was not included in any of the pain or emotion prototypes examined, had a minimum 70% coding reliability (Intercoder Reliability = 99%), occurred more often than 5% of the time (Percent Occurrence = 46.4% of the time it could be observed) and has been associated with pain in previous research (Craig & Patrick, 1985; Patrick et al., 1986; LeResche & Dworkin, 1988), reliable mean differences in its occurrence between baseline and pain periods were not observed. Paired samples *t*-tests indicated that the occurrence of AU 45 Blink did not reliably differ during baseline (M = 46.75, SD =26.22) and during cold pressor pain (M = 46.68, SD = 24.53), Paired samples t (119) = -.03, p = .97. Accordingly, AU 45 Blink was excluded from further analyses.

Cold Immersion Time

A 3 (audience condition) X 2 (participant sex) X 2 (experimenter sex) ANOVA was used to examine differences in cold immersion time. Assumptions of a Fixed-Effects ANOVA were examined. A Kolmogorov-Smirnov Goodness of Fit Test indicated that the distribution of cold immersion times deviated significantly from a standard normal distribution [Z (120) = 5.10, $p <$ .001]. The data were negatively skewed (*Fisher's skew* = -1.40, SE = .22), which indicated that the bulk of participants tended to leave their hand in the cold water for longer periods of time. In a Fixed Effects ANOVA with equal *n*'s, the consequences of violation of assumptions of normality with respect to skewness appear to have very little effect on either the level of significance or the power (Glass & Hopkins, 1996). No other assumptions were violated. Mean immersion times (scale: 0 to 180 seconds) for the experimenter absent group (M = 149.40 seconds, SD = 58.04), experimenter observing unseen group (M = 150.32 seconds, SD = 57.27) and experimenter present group (M = 147.75, SD = 56.89) did not reliably differ from each other [F (2, 108) = .021 , p = .98, Partial η2 < .01]. The differences among group means were less than four seconds, which was judged not to be clinically significant when considered across a possible time frame of 180 seconds. No reliable main effects of participant sex [F (1, 108) = 2.86, p = .10, Partial η2 = .02] or experimenter sex [F (1, 108) = .1.03, p = .31, Partial η2 = .01] were observed. No reliable two-way or three-way interactions among audience condition, participant sex and/or experimenter sex were observed ($p > .10$).

The role of cold immersion time as a mediator between audience condition and facial expression of pain was also considered. According to criteria set by Baron and Kenny (1986), a variable functions as a mediator when it meets three conditions, the first of which is that variations in levels of the independent variable significantly account for variations in the presumed mediator. Because variations in audience condition did not significantly account for variations in cold immersion time, it was not considered to be a mediator variable in this case.

Heart Rate

A 3 (audience condition) X 2 (participant sex) X 2 (experimenter sex) ANOVA was conducted to examine whether these variables influenced heart rate residualized change scores (these scores emphasize the portion of interindividual variability seen in average heart rate during the cold pressor task that cannot be predicted from a knowledge of the variability that exists in average heart rate and among the same individuals in the one minute prior to the cold pressor task). No statistically reliable differences in mean heart rate residualized change scores between audience groups were observed [F (2, 117) = .37, p = .68, Partial η2 = .006]. No reliable main effects of participant sex [F (1, 108) = 1.00, p = .31, Partial η2 = .01] or experimenter sex [F (1, 108) = 1.33, p = .25, Partial η2 = .01] were observed. No reliable two-way or three-way interactions among audience condition, participant sex and/or experimenter sex were observed ($p > .10$).

The role of heart rate change as a mediator between audience condition and facial expression of pain was also considered. According to criteria set by Baron and Kenny (1986), heart rate was not a mediator variable because variations in audience condition did not significantly account for variations in heart rate.

Self-report Measures

Pearson correlations were calculated. The self-report VAS severity ratings were reliably and positively correlated with the VRS sensory intensity ratings ($r = .52$, $p < .001$, $N = 120$) and the VRS unpleasantness ratings ($r = .51$, $p < .001$, $N = 120$). In addition, the VRS sensory intensity and unpleasantness were reliably and positively correlated with each other ($r = .49$, $p < .001$, $N = 120$). Using cutoffs of .90 or higher for statistical problems and .70 or higher for logical problems (Tabachnick & Fidell, 2001), multicollinearity was judged non-problematic. In their discussion of whether to use MANOVA versus ANOVA, Tabachnick and Fidell (2001) suggest that MANOVA works acceptably well with moderately correlated dependent variables. Because the separate self-report measures were theoretically important in their own right and most displayed at least some empirical independence, MANOVA was selected as the appropriate technique.

A 3 (audience condition) X 2 (participant sex) X 2 (experimenter sex) between groups MANOVA was conducted to examine whether these variables influenced a linear composite of self-reported VAS ratings of pain intensity, self-reported VRS score of pain unpleasantness, and self-reported VRS score of pain unpleasantness. No significant multivariate effect was found for audience condition, Wilks Lambda F (6, 212) = .95, p = .45, Partial η2 = .02, indicating that a linear composite of self-report ratings of pain did not vary as a function of the audience conditions examined. The raw means and standard deviations for self-reported VAS and VRS ratings are reported in Table 12.

Examination of the clinical descriptors associated with the group means reported for each scale also did not reveal group differences. When clinical interpretation guidelines by Jensen, Chen and Brugger (2003) are applied to the VAS, the mean score for each group was interpreted as “moderate”. As well, the differences among mean scores do not reach the lowest estimate, 9 mm, of a minimal clinically significant difference in acute pain experience as measured by VAS pain scores in the literature (Kelly, 1998). Matching the VRS means to their closest verbal descriptor on the scale (Gracely, Dubner, & McGrath, 1979), the mean pain intensity score for each group was interpreted as “intense” and mean pain unpleasantness score for each group was interpreted as “very distressing”. No statistical analyses were applied, as the descriptors for each group were identical.

No reliable main effects of participant sex [F (3, 106) = 2.27, p = .08, Partial η2 = .06] or experimenter sex [F (3, 106) = .93, p = .42, Partial η2 = .02] were observed. No reliable two-way or three-way interactions among audience condition, participant sex and/or experimenter sex were observed ($p > .10$).

Although measuring pain experience is challenging, self-reports are often used as measures to approximate the experience. To explore the potential role of changed experience as a mediator for changed facial expression, the role of self-reports as a mediator between audience condition and facial expression of pain was considered. According to criteria set by Baron and Kenny (1986), verbal self-reports were not mediator variables because variations in audience condition did not significantly account for variations in verbal self-reports.

Table 12

Descriptive Statistics: Means (Standard Deviations) Self-reported and Judges' Ratings of Pain as a Function of Audience Condition

	VAS – Pain (0 – 100 scale)		VRS – Intensity (0-59.5 scale)		VRS – Unpleasantness (0-44.8 scale)	
Group[a]	Self	Judge	Self	Judge	Self	Judge
Absent	65.8	46.5	37.18	24.87	18.84	11.66
	(16.34)	(22.0)	(11.736)	(18.54)	(10.62)	(8.16)
Unseen	62.3	34.7	32.25	14.19	18.17	7.83
	(21.00)	(17.3)	(10.22)	(14.70)	(11.48)	(6.08)
Present	66.2	30.5	33.54	15.54	17.65	7.27
	(16.32)	(14.8)	(12.34)	(13.23)	(11.29)	(5.69)

Note. Clinical descriptors for interpretation of the numerical values of the 100-mm VAS ratings: 0 to 4 mm = no pain, 5 to 44 mm = mild pain, 45 to 74 mm = moderate pain, and 75 to 100 mm = severe pain (Jensen, Chen, & Brugger, 2003). Estimates of the minimal clinically significant difference in acute pain experience as measured by VAS pain scores ranges from 9mm (Kelly, 1998) to 13 mm (Todd, 1996). [a]*n* = 40 for each group.

Judges' Ratings

Inter-Judge Reliability

For the twelve untrained observers' global ratings of participants' pain severity, intensity and unpleasantness, reliabilities were calculated using intraclass correlations. A 2-way random effect model (participant and observer effects random) was selected using the guidelines set forth by Shrout and Fleiss (1979). Each of the 120 videoclips was rated by each of the same twelve judges and generalization to other raters within the same population was desired. An absolute agreement definition was selected over a consistency definition because systematic differences among levels of ratings are considered relevant (Nichols, 1998).

Reliabilities of Units of Analyses

To inform decisions about whether the scores from the twelve different judges could be pooled into one average score for each measure for use in subsequent analyses, average measure intraclass correlations were calculated. For VAS-pain severity ratings, the average measure intraclass correlation was .87 [F (119, 1309) = 10.88, $p < .001$]. For VRS-sensory intensity ratings, the average measure intraclass correlation was .86 [F (119, 1309) = 9.91, $p < .001$]. For VRS-unpleasantness ratings, the average measure intraclass correlation was .86 [F (119, 1309) = 9.80, $p < .001$]. The average measure intraclass correlations were judged to be sufficiently reliable according to a pre-set criterion of .80 or greater. Judges' ratings were pooled as overall "average" scores for each measure. The mean of all judges' ratings was the unit of analysis in subsequent analyses.

Reliabilities of Units of Generalization

Although judges' mean pain ratings were selected as the unit of analysis for further study, we would also like to be able to generalize the results to single observers (not to other groups of twelve observers). For this purpose, Fleiss and Shrout (1979) recommend also calculating single measure intraclass correlations. Using a two way random effects model and an absolute agreement definition the single measure intraclass correlation was .36 [F (119, 1309) = 10.88, $p < .001$] for VAS-pain severity ratings, .33 [F (119, 1309) = 9.91, $p < .001$] for VRS-sensory intensity ratings, and .35 [F (119, 1309) = 9.80, $p < .001$] for VRS-unpleasantness ratings. These correlations are low and suggest that generalization of results to a single observer is unwise.

Judges' Ratings of Pain

The means of judged VAS global pain ratings, VRS sensory intensity ratings, and VRS unpleasantness ratings were reliable, theoretically related, as well as significantly and highly correlated. The judged VAS ratings were positively correlated with the VRS sensory intensity ratings ($r = .71$, $p < .001$, $N = 120$) and the VRS unpleasantness ratings ($r = .89$, $p < .001$, $N = 120$). In addition, the VRS sensory intensity and unpleasantness were positively correlated with each other ($r = .70$, $p < .001$, $N = 120$). Using cutoffs of .90 or higher for statistical problems and .70 or higher for logical problems (Tabachnick & Fidell, 2001), multicollinearity was judged to be logically problematic. Tabachnick and Fidell (2001) suggest that using univariate tests on highly correlated variables are misleading because they suggest effects on different behaviours when actually one behaviour is being measured repeatedly. Instead, they advocate using a strategy such as picking the most reliable single dependent variable for use in ANOVA. The VAS score was chosen for the following reasons: (1) it was the most reliable measure, (2) it is widely used in pain research and clinical settings, (3) its psychometric properties are good, and (4) it appears to integrate both sensory and affective qualities of pain as well as any other multidimensional aspects subjectively important to participants or judges by asking globally about pain.

A 3 (audience condition) X 2 (participant sex) X 2 (experimenter sex) between-groups ANOVA was conducted to examine whether these variables influenced judges' VAS pain ratings. Audience condition reliably influenced judges' VAS pain ratings, F (2, 108) = 8.01, $p = .001$, $\eta 2 = .13$. No reliable main effects of participant sex [F (1, 108) = .26, $p = .60$, Partial $\eta 2 <$

.01] or experimenter sex [*F* (1, 108) = 1.54, *p* = .21, Partial η2 = .01] were observed. No reliable two-way or three-way interactions among audience condition, participant sex and/or experimenter sex were observed (*p* > .10).

Tukey post hoc tests revealed that judges rated the experimenter absent group (*M* = 46.5, *SD* = 22.0) as experiencing more pain than the experimenter observing unseen group (*M* = 34.7, *SD* = 17.3), *p* = .013, and the experimenter present group (*M* = 30.5, *SD* = 14.8), *p* < .001. The latter two groups did not differ from each other.

The statistically significant differences among means observed also appear to be clinically significant. The means varied more than 10mm on a 101 mm VAS. Minimal clinically significant difference in self-reported acute pain experience as measured by VAS pain scores have been judged to range between 9mm (Kelly, 1998) to 13 mm (Todd, 1996). Extending the Kelly (1998) guideline to judges' perceptions of pain in the participants would confirm that the observed differences would be judged to be a clinically significant difference between the experimenter absent group and the experimenter observing unseen group (11.8 mm) if this were observed in patients. The difference between the experimenter absent group and the experimenter present group (16 mm) would meet the even more stringent minimal clinical significant difference criterion (Todd, 1996). As well, using criteria specified by Jensen, Chen, and Brugger (2003), the mean pain attributed to participants in the experimenter absent group (*M* = 46.5) corresponds to the clinical descriptor "moderate pain" while the means for the experimenter observing unseen group (*M* = 34.7) and experimenter present group (*M* = 30.5) correspond to the clinical descriptor "mild pain".

Judges' Ratings of Facial Expressiveness

A Kruskal-Wallis H test was performed to investigate whether judges' ratings of participants' overall facial expressiveness varied as a function of audience condition. The test variable was ratings made on a three point ordinal scale (1 = inexpressive, 2 = somewhat expressive and 3 = very expressive). The grouping variable was audience condition. The Kruskal-Wallis H test indicated that the judgments were not similar in all the audience conditions [H (2) = 15.02, p = .001]. In order from highest to lowest the mean ranks were: experimenter absent group (Mean rank = 75.13) experimenter observing unseen group (Mean rank = 56.63) and the experimenter present group (Mean rank = 49.75).

Three Mann-Whitney U tests were used to follow up the statistically significant Kruskal-Wallis H test. A Bonferroni correction of the alpha was applied (.05 / 3 = .0167) in order to maintain the overall probability of a type I error at 0.05. Judges' ratings of facial expressiveness were reliably higher for the experimenter absent group compared to the experimenter observing unseen group (U = 545.00, p = .007) and the experimenter present group (U = 470.00, $p < .001$). However, no reliable differences in judges' ratings of facial expressiveness were observed between the experimenter observing unseen group and the experimenter present group (U = 700.00, p = .23).

Judges' Pain Management Assessments

A Kruskal-Wallis test was performed to investigate whether judges' perceptions of the need for pain management differed as a function of audience condition. The test variable was ratings made on a five point ordinal scale ranging from 0 (*definitely no*) to 4 (*definitely yes*) in response to the question "Do you think that the level of pain that you just witnessed warrants pain relief?". The grouping variable was audience condition. The Kruskal-Wallis test indicated that the pain management judgments were not similar in all the audience conditions, *H* (2) = 10.36, $p = .006$. In order from highest to lowest the mean ranks were: experimenter absent group (Mean rank = 74.40), experimenter observing unseen group (Mean rank = 56.99), and the experimenter present group (Mean rank = 50.11).

Three Mann-Whitney U tests were used to follow up the statistically significant Kruskal-Wallis H test. A Bonferroni correction of the alpha (.05/3 = .0167) was applied in order to maintain the overall probability of a type I error at .05. Pain management judgments were reliably higher for the experimenter absent group compared to the experimenter present group ($U = 471.00$, $p = .002$). No reliable differences in pain management judgments were observed between the experimenter absent group and the experimenter observing unseen group ($U = 572.50$, $p = .029$), or between the experimenter observing unseen group and the experimenter present group ($U = 713.00$, $p = .40$).

Discrepancies between Self-reports and Judges' Ratings of Pain

Visual Analog Scale ratings (scale: 0-100) were selected as the dependent variable components for the reasons outlined in the section on judges' ratings. A Paired Sample *t*-test indicated that verbal reports of pain using the VAS differed as a function of whether the reporter was the person in pain (self-report) or an observer judging pain (other-report). Using a VAS, self-report ratings ($M = 64.92$, $SD = 17.96$) were higher than other-report ratings ($M = 37.29$, $SD = 19.47$), [t (119) = 13.10, $p < .001$]. The discrepancy of 27.63 mm is above estimates of the minimal clinically significant difference in acute pain experience as measured by VAS pain scores, which range from 9mm (Kelly, 1998) to 13 mm (Todd, 1996). Using VAS interpretation guidelines provided by Jensen, Chen and Brugger (2003), the difference appears to be clinically important as the self-report mean ratings can be interpreted as moderate pain (45 to 74 mm), while the other-report ratings can be interpreted as mild pain (5 to 44 mm).

Differences scores were constructed by subtracting the mean of judges' ratings from the participants' ratings. Accordingly, positive values indicate that self-report ratings were higher than judges' ratings. A 3 (audience condition) X 2 (participant sex) X 2 (experimenter sex) between-groups ANOVA was conducted to examine whether these variables influenced discrepancies between self-reports and judges' ratings of pain as measured by the VAS. Audience condition significantly influenced discrepancies between self-reports and judges' ratings of pain as measured by the VAS [F (2, 108) = 5.37, p = .006, η2 = .09]. No reliable main effects of participant sex [F (1, 108) = 1.26, p = .26, Partial η2 = .01] or experimenter sex [F (1, 108) = .05, p = .80, Partial η2 < .01] were observed. No reliable two-way or three-way interactions among audience condition, participant sex and/or experimenter sex were observed (p > .10).

Tukey post hoc tests revealed that the differences between self-reports and judges' ratings for the experimenter absent group were smaller (M = 19.26, SD = 23.84) than the experimenter present group (M = 35.75, SD = 20.93) p = .004. The mean difference was 16.4 mm on a 100 mm VAS, which is above estimates of minimal clinically significant differences in acute pain experience (Kelly, 1998; Todd, 1996). No other comparisons were statistically significant.

Next, a one-way between groups ANCOVA was conducted to explore whether the significant main effect of audience condition on differences between self-reports of pain and judges' ratings remained significant after controlling for the variance due to facial expression of pain. The results of the ANCOVA revealed that the group differences were no longer reliable at a p = .05 level after controlling for facial expression, F (2, 116) = 2.61, p = .07, and less variance was accounted for by audience condition, *Partial η2* = .04. A significant negative correlation between pain prototype face and discrepancy between self-report and judges ratings of pain was observed (r = -.43, $p < .001$, N = 120).

Correlations Among Pain Facial Expressions, Self-reports, and Judges' Ratings

Correlations among representative measures of pain facial expressions, self-report pain ratings and judges' pain ratings for all participants, broken down by audience condition, are reported in Table 13. For all participants (alpha set at .05 per correlation), facial expressions of pain were reliably associated with judges' ratings, but not self-report ratings. Judges' ratings and self-report ratings were reliably associated with each other. For correlations broken down by audience group (alpha set at .01 per correlation), facial expression of pain was reliably, positively correlated with judges' ratings in the experimenter absent group and the experimenter observing unseen group.

Table 13

Pearson Correlations Among Pain Self-report, Facial Expression, and Judges' Ratings

Group	n	Self-reports - Facial Expression	Facial Expression - Judges' Ratings	Self-reports - Judges' Ratings
Absent	40	.08	.68***	.25
Unseen	40	.26	.60***	.36
Present	40	.08	.34	.09
All	120	.12	.63***	.23**

Note. The VAS was selected to represent self-report and judge ratings. The mild pain face prototype was used to represent facial expression.

*$p < .05$, ***$p < .01$, ***$p < .001$.

Building a Model of Pain Expression: Predictors of Facial Expression During Pain

An ANOVA indicated that the percent occurrence of the mild pain prototype face during the cold pressor task differed as a function of experimenter audience condition, which accounted for seven percent of the display variance. Exploratory regression analyses were conducted to explore other factors that may explain unaccounted variance. Similar to the rationale for the ANOVA, occurrence of the mild pain prototype pain face during the baseline period was not used as a covariate or predictor because it was not observed. For the purposes of the regression, some variables that were previously treated as dependent variables (cold immersion time, heart rate, self-reports) were utilized as predictors of facial expression during pain.

A sequential logistic regression analysis was performed to assess prediction of outcome (pain face display: Yes or No), first on the basis of three pain self-report predictors (VAS Pain, VRS Pain Intensity, and VRS Pain Unpleasantness), then after addition of cold immersion time, then after addition of heart rate, then after addition of two suspiciousness ratings (overall and videotape), then after addition of Self-Monitoring Scale-Revised scores, then after sex-related variables (participant sex, experimenter sex, and participant X experimenter interaction), then after addition of visible minority status, and, finally, after addition of experimenter audience condition.

The predictor audience condition, which was initially comprised of three discrete categories (experimenter absent, experimenter observing unseen and experimenter present), was converted into a set of two dichotomous variables by dummy variable coding (per guidelines by Cohen & Cohen, 1983). The experimenter observing unseen group was selected as the reference group. Dummy Variable 1 was comprised of experimenter absent group and experimenter observing unseen group (reference group). Dummy Variable 2 was comprised of the experimenter observing unseen group (reference group) and the experimenter present group. The new dummy variables were entered into the regression as a group (as recommended by Fox, 1991) so the variance due to the original discrete predictor could be examined along with the effects of the newly created dichotomous components.

The number of cases (N = 120) is above the minimum rule of thumb requirement (number of cases must be greater than or equal to 104 plus the number of predictors) suggested by Tabachnick and Fidell (2001). Specifically 118 would be the minimum number of cases required to test fourteen individual predictors in multiple regression using this formula.

Step 1: Pain Self-report Predictors

A logistic regression was conducted to assess if self-reported VAS Pain, VRS Pain Intensity, and VRS Pain Unpleasantness predicted pain face display (Yes or No). The self-report predictors accounted for 4.8% of pain face display variance. However, the predictors did not reliably predict pain face display, ($\chi^2 = 4.53$, $df = 1$, $p = .20$).

Step 2: Adding Cold Immersion Time Predictor

An additional logistic regression was conducted to assess if cold immersion time would increase the prediction of likelihood of observing the pain face if it were added to the predictors used in the previous step. The addition of cold immersion into the regression equation accounted for an additional 0.9% of pain face display variance. However, pain self-reports and cold immersion time did not reliably predict pain face display, ($\chi^2 = 0.86$, $df = 1$, $p = .35$).

Step 3: Adding Heart Rate Predictor

The addition of the predictor heart rate into the regression equation accounted for an additional 4.0% of pain face display variance. Results of the regression indicated that the predictors reliably predicted pain face display, ($\chi^2 = 3.89$, $df = 1$, $p < .05$). For every one unit increase in residualized change heart rate scores, participants were 1.05 times more likely to display a pain face.

Step 4: Adding Suspiciousness Predictors

The addition of the overall suspiciousness and suspiciousness of being videorecorded as predictors into the regression equation accounted for an additional 0.7% of pain face display variance. The predictors did not reliably predict pain face display, ($\chi^2 = 0.68$, $df = 1$, $p = .71$).

Step 5: Adding Self-monitoring Predictor

The addition of Self-monitoring Scale-Revised scores (SMS-R) as a predictor into the regression equation accounted for an additional 7.6% of pain face display variance. Together, the predictors reliably predicted pain face display, ($\chi^2 = 7.93$, $df = 1$, $p < .01$). For every one unit increase in heart rate change, pain face display was 1.05 times more likely to occur. For every one unit increase in SMS-R score, pain face display was 1.18 times more likely to occur.

Step 6: Adding Sex Predictors

The addition of sex predictors (Participant Sex, Experimenter Sex, and Participant Sex X Experimenter Sex Interaction) into the regression equation accounted for an additional 1.1% of pain face display variance. The predictors did not reliably predict pain face display, ($\chi^2 = 1.15$, $df = 1$, $p = .28$).

Step 7: Adding Visible Minority Status Predictor

A subsequent logistic regression was conducted to assess if the visible minority status would increase the prediction of likelihood of observing the pain face if it were added to the predictors used in the previous step. The addition of the predictor visible minority status into the regression equation accounted for no (0%) additional pain face display variance. The predictors did not significantly predict pain face display, ($\chi^2 = 0.01$, $df = 1$, $p = .94$).

Step 8: Adding Experimenter Audience Predictors

Finally, a logistic regression was conducted to assess if adding the experimenter audience groups would increase prediction of the likelihood of observing a prototypical pain face during the cold pressor task. The addition of the experimenter audience predictors Dummy 1 (1= absent, 0 = unseen) and Dummy 2 (1 = present, 0 = unseen) into the regression equation accounted for an additional 12.2% of pain face display variance. The model was statistically significant, X (14) = 36.78, $p < .001$ (Nagelkerke R-square = .264), and correctly classified 84.2% of the cases. The classification table for the final regression model is presented in Table 14. The odds ratios (Exp (b)) for predictors of the pain face display are presented in Table 15. For every one unit increase in residualized change heart rate scores, participants were 1.05 times more likely to display a pain face. For every one unit increase in Self-Monitoring Scale-Revised scores, participants were 1.18 times more likely to display a pain face. As the context became lower in sociality, participants were 4.75 times more likely to display a pain face.

Table 14

Classification Table for Regression Model

			Predicted		
			Pain Face		Percentage Correct
			No	Yes	
Observed	Pain Face	No	89	5	94.7
		Yes	14	12	46.2
	Overall Percentage				84.2

Table 15

Summary of the Last Step of a Sequential Logistic Regression Analysis for Variables Predicting Display of a Mild Pain Face Prototype During the Cold Pressor (N = 120)

Predictors	*B*	*SE*	*Wald*	*Exp (b)*
VAS Pain	0.01	0.02	0.11	1.01
VRS Pain Intensity	0.02	0.03	0.94	1.02
VRS Pain Unpleasantness	0.01	0.03	0.27	1.01
Cold Immersion Time	0.00	0.00	0.82	1.00
Heart Rate Change	0.05	0.03	4.18*	1.05
Suspiciousness Overall	0.00	0.01	0.14	1.00
Suspiciousness Video	0.01	0.01	1.04	1.01
Self-monitoring Scale-Revised Score	0.16	0.07	5.99*	1.18
Participant Sex	-0.12	0.47	0.06	0.89
Experimenter Sex	0.53	0.48	1.24	1.70
Sex Interaction	-0.01	0.01	0.61	0.99
Visible Minority Status	0.07	0.47	0.02	1.07
Experimenter Sociality 1 (absent, unseen)	1.56	0.57	7.58**	4.75
Experimenter Sociality 2 (present, unseen)	-0.41	0.52	0.62	0.66

Suspiciousness

Suspiciousness - Quantitative Data

On a scale ranging from 0 (*not suspicious*) to 100 (*extremely suspicious*), the participants reported a moderate level of general suspicion (*M* = 26.71, *SD* = 27.78, *N* = 120) and a low level of suspicion about being videotaped (*M* = 11.28, *SD* = 22.48, *N* = 120). Two univariate between-groups ANOVAs were conducted to establish whether the randomization process was associated with significant differences between experimenter audience groups on any of these variables. Mean general suspiciousness ratings (scale: 0 to 100) for the experimenter absent group (*M* = 29.10, *SD* = 28.09), experimenter observing unseen group (*M* = 25.05, *SD* = 28.84), and experimenter present group (*M* = 26.00, *SD* = 26.93) did not differ from each other reliably [*F* (2, 117) = .22, *p* = .79, Partial $\eta 2$ = .004]. Mean videotape suspiciousness ratings (scale: 0 to 100) for the experimenter absent group (*M* =9.55, *SD* =17.65), experimenter observing unseen group (*M* =13.30, *SD* = 26.22), and experimenter present group (*M* = 11.00, *SD* =23.14) also did not differ from each other reliably [*F* (2, 117) = .27, *p* = .75, Partial $\eta 2$ = .005].

The role of suspiciousness as a mediator between audience condition and facial expression of pain also was considered. Since variations in audience condition did not significantly account for variations in suspiciousness scores, suspiciousness was not considered as a mediator variable (Baron & Kenny, 1986).

As a group, participants in the experimenter absent group (*n* = 40) retrospectively reported a moderate general level of suspicion about being observed (e.g., *M* = 37.80, *SD* = 32.03). Participants ranged in reported suspicion of being observed from 0 (not suspicious) to 100 (extremely suspicious) on a 101-point scale, with the median (35) similar to the mean (37.8). Pearson bivariate correlations indicated that suspiciousness of being watched was not reliably associated with pain behaviours. Suspiciousness about being observed was not significantly correlated with the following variables (*n = 40)*: mild pain face prototype display (*r* = .16, *p* = .31), cold immersion time (*r* = -.13, *p* = .39), heart rate change, (*r* = -.02, *p* = .89), VAS severity ratings (*r* = .15, *p* = .35), VRS sensory intensity ratings (*r* = .20, *p* = .21), VRS unpleasantness ratings (*r* = .23, *p* = .14).

A direct logistic regression analysis was performed on pain face display (Yes or No) as the outcome and suspiciousness of being watched as the predictor. The model (tested against a constant-only model) was not statistically significant, χ^2 (1, *n* = 40) = 1.02, *p* = .31. Suspiciousness of being watched did not reliably distinguish between participants who showed the pain face and participants who did not show the pain face. Nagelkerke R Square indicated that suspiciousness of being watched accounted for .04% of the pain face display variance. Regression coefficients were *B* = .01, *SE* = .01 and *Exp (B)* = 1.01. According to the Wald criterion, suspiciousness of being watched did not reliably predict display of pain face, *z* = 1.00, *p* = .31.

Suspiciousness – Qualitative Data

Because the quantitative ratings did not indicate that participants' suspiciousness was related to their facial expression during the cold pressor task (see section on building a model of facial expression), qualitative data on participants' suspiciousness are not reported here.

Self-Monitoring

Because scores on the Self-Monitoring Scale-Revised predicted the likelihood of observing a prototypical mild pain face during the cold pressor task, some exploratory analyses of moderation were conducted. Based on a median split, participants were classified as either low (SMS-R score less than 10, n=54) or high (SMS-R score 10 or greater, n=66) self-monitors. This split is consistent with Snyder's (1987) recommendation that median split scores of 10 are appropriate for use with North American university students. A series of 3 between (audience condition) X 2 between (self-monitoring tendency) X 2 within (time) ANOVAs were conducted to determine the influence of these variables on facial expression. Three indices of facial expression were chosen for exploration as dependent variables: 1) prototypical facial expressions of mild pain (brow lower plus orbital tightening or eyes closing), 2) prototypical facial expressions of disgust (upper lip raise), and 3) smiling (lip corner pull). No reliable main effects of self-monitoring groups or interactions among self-monitoring groups and audience conditions were observed for any of the variables examined ($p > .15$). Main effects of audience condition were observed and were described previously.

To ensure that the lack of differences was not due to a false dichotomization of participants into self-monitoring groups, an additional strategy for dividing participants into groups was applied. Participants were divided into three groups using a percentiles strategy. Participants falling at the 25th percentile or below (scores of 8 or lower on the SMS-R) were classified as low self-monitors, participants falling at the 75th percentile or above (scores of 13 or higher on the SMS-R) were classified as high self-monitors, and participants falling in the 25th to 75th percentile range were classified as average self-monitors. Use of this alternative strategy for dividing participants based on their self-monitoring scores did not change the results. Once again, no reliable main effects of self-monitoring groups or interactions among self-monitoring groups and audience conditions were observed for any of the variables examined ($p > .15$).

The lack of reliable interactions between self-monitoring tendency and audience conditions suggest that self-monitoring scores did not moderate the relationship between audience condition and facial expression in the present study. However, the lower power for these analyses suggests that this conclusion must be interpreted with some caution.

DISCUSSION

Summary and Discussion of Findings

Overview

The communication of pain has important functions for the person in pain and other people in environment. In the present study, we explored the interpersonal nature of facial expressions during pain.

Overall, the hypothesis that facial expressions during pain would be influenced by social factors as basic as the presence of another person was supported. The direction of the modulation of facial expression depended on the sociality (the degree to which the situation supposes the presence of others) of the experimenter context and on the particular facial action configurations examined. Pain faces occurred more often when participants were alone in the testing room. If the facial expressions while alone can be considered the most closely related to inner processes and the least socially influenced, then the pattern of results may be interpreted as suppression of pain expression in the presence of an experimenter. The visibility or actual presence of the experimenter was not required for a relative social attenuation of pain faces. A similar pattern was found for disgust faces during pain. A contrasting pattern was observed for happy faces during pain. Happy faces occurred less often when participants were alone in the testing room. In this case, the visibility of the experimenter was required for social facilitation of happy faces. The pattern of results indicated that the presence of an experimenter during pain had an inhibiting effect on facial expressions of pain and disgust, but a facilitating effect on facial expressions of happiness.

The results also support the hypothesis that facial expression is a unique pain communication modality and should not be interpreted as a simple read-out of the pain experience. Discordance between different measures of pain expression was observed. Facial expression was not related to verbal self-reports of pain. As well, when facial movements during exposure to the cold pressor were coded using a detailed component system (FACS), a relatively low incidence of configurations of facial actions associated with pain were found, despite self-report of pain. Facial expressions of pain were better predicted by audience context than self-report ratings. Objectively coded facial expressions during pain were associated with naïve judges' ratings of pain, suggesting that audience group differences were meaningful and perceived by others. Overall, considerable within group and between group variability in facial expressions of pain were observed.

Audience Effects on Facial Expressions of Pain

When assessing pain in others, people commonly use facial expression as a clue to intrapersonal pain processes (Pillai Riddell, Badali, & Craig, 2004; Kim, Schwartz-Barcott, Tracy, Fortin, & Sjöström, 2005). While facial expression during pain can provide information about personal pain experience, facial expression is also sensitive to the social context. In the present study, we demonstrated that facial expressions during pain depend on whether someone is watching. During painful stimulation in a laboratory setting, facial expressions of pain occurred less often and in fewer participants when they were in the presence of an experimenter compared to when they were alone. Differences in the impact on facial expression of pain between being alone and being alone with the explicit awareness that an experimenter was observing depended on the measurement of facial expression of pain utilized. Whether or not a pain face was observed in participants differed between these conditions. In contrast, the overall amount of time pain faces were observed did not differ between these conditions. We suspect that the lack of a statistically reliable difference using the latter measurement may be related to the high variability in facial expression among participants. However, it may also be that the social context manipulation was more likely to exert its influence on the former measurement. Indeed, audience context accounted for less variance (7% of general variance) in the duration of time the pain face was observed during pain than for the variance in the likelihood of participants displaying the pain face (12.2% of unique variance). Taken together, the results from the present study confirm that experimenter presence can significantly influence facial expression during pain.

The results from the present study can be integrated with past literature in order to gain a greater understanding of the effects of audience on facial expression of pain in laboratory settings (see Table 16).

The findings of the present study showing that facial expressions of pain were observed more often and in more people when participants were alone converge with research by Kleck and colleagues (1976) indicating greater pain judgments of participants who were alone during electric shock pain compared to those observed through a one-way screen by a confederate peer. The current findings also converge with research by Badali (2000) indicating greater pain judgments of participants who were alone during cold pressor pain compared to those who were in the presence of a confederate peer. The convergence observed extends the results from previous studies to a context in which the audience was an experimenter rather than a confederate posing as a peer.

Table 16.

Audience Effects on Facial Expression of Pain: Integrating the Results

Reference	Participants	Control Condition	Audience Conditions	Dependent Measure	Results
Present study	60 Females, 60 Males	Alone (hidden camera)	Experimenter (visible & not visible)	FACS coding & Judges' ratings	Social inhibition
Badali (2000)	60 Females, 60 Males	Alone (hidden camera)	Female peer or Male peer (visible)	Judges' ratings	Social inhibition
Kleck et al. (1976)	20 Males	Alone (hidden camera)	Female peer (not visible)	Judges' ratings	Social inhibition
Kleck et al. (1976)	40 Males	Alone (hidden camera)	Female peer or Male peer (not visible)	Judges' ratings	Social inhibition
Sullivan et al (2004)	26 Males, 38 Female	Alone (obvious camera)	Female observer (visible)	Judges' ratings	Social facilitation in high C; no effects in low C
Wang (2005)	104 Females	None	Friend or Stranger (visible)	FACS coding	No effects

Note. Participants in all studies were undergraduate students. In the studies by Kleck et al. (1976) and by Badali (2000), the peer observer was actually a confederate. Shock was used by Kleck et al. as a pain stimulus and all others used the cold pressor task. C = catastrophizing.

There are limits on the proposition that social inhibition of facial expressions of pain in the presence of a stranger would be invariant. The results from the present study differ from the findings of Sullivan, Adams, and Sullivan (2004), who reported that participants in the presence of a female observer showed "more exaggerated" facial expression (operationally defined as a longer duration) than participants who were being openly videotaped while alone, but only if they were prone to high levels of pain catastrophizing (emphasizing the negative features of painful events). The audience effects for individuals categorized as high pain catastrophizers were explained using the communal coping model of pain catastrophizing (Sullivan et al., 2001), which proposes that individuals vary in the extent that they might engage in exaggerated displays of their pain-related distress as a means of coping with pain. When considered in the context of the present study, it may be that high catastrophizers or individuals attempting to engage with others actually show more uninhibited expressions rather than exaggerations.

At first, the present results appear to diverge from Sullivan et al's (2004) finding of no effects of observer presence on the facial expressions emitted by low catastrophizers. Upon closer inspection, the results are more consistent. Individuals in *both* the alone group and the observed group of Sullivan and colleagues' study were *aware* that they were being videotaped. This contrasts with the surreptitiously concealed camera methodology employed in the present study and other examinations of pain behaviour that found general social inhibition effects (Kleck et al., 1976; Badali, 2000). Accordingly, when compared to the present study, Sullivan and colleagues' alone condition may be more similar to the experimenter observing unseen condition than the experimenter absent condition. Hence, the results of Sullivan and colleagues for low catastrophizers are actually comparable to lack of differences observed between the experimenter observing unseen condition and the experimenter present condition in the present study. While Sullivan's hypothesis that social factors may account for more variance in the facial expressions during pain of high catastrophizers appears to have substance, it may be premature to rule out the effects of social factors on facial expressions of low catastrophizers. More research with larger samples (ensuring adequate statistical power to reveal between group differences) is required to confirm a lack of audience effects for low catastrophizers.

There were additional methodological differences between the study conducted by Sullivan and colleagues (2004), who found an audience facilitation effect in high catastrophizing participants, and studies by Kleck and et al. (1976), Badali (2000) and the present study, which reported audience inhibition effects. The latter researchers collected verbal self-report measures immediately following the pain stimulus, whereas Sullivan et al. collected verbal self-report measures at routine intervals during the pain stimulus. This methodological difference may have led to artifactual influences on facial expression. For example, participants may have become more self-aware of making facial expressions consistent with their self-reports. Low catastrophizers may have not been as influenced by the propensity to use facial expression as a social signal to communicate pain as their self-reports were being recorded. Increased understanding of the role of the "directness" of observer presence, perceptions of social motives, and display rules on facial expression would help us understand results of studies investigating social influences on pain.

Results from the present study support Craig and colleagues' Sociocommunications Model of Pain. The observed audience effects provide empirical support for the theory that facial expressions associated with pain can be viewed as at least partly communicative or interpersonal acts because they demonstrate the sociality of the displays.

The presence of an audience clearly affected the communication of pain. It is less clear at what point in the communication process its influence was exerted. Audience effects may have been exerted directly on facial expression or indirectly on facial expression via an impact on the pain experience and then subsequent translation into corresponding behavioural changes. The pattern of results suggests that the former explanation is more likely. No differences between audience groups with respect to verbal self-reports of pain or heart rate changes were observed. As well, the relationships among facial expression during pain and other indices of pain experience were weak. We conclude that the effects of the audience were on pain expression rather than pain experience.

From a social learning perspective, the observed social modulation of facial expression could be explained by the operation of display rules, conventions for attenuating, intensifying, or masking involuntary facial expressions in public (Ekman, 1972). A social inhibition display rule may operate in pain laboratory settings, as relative attenuation of facial expression of pain in the presence of strangers was observed. The results were consistent with previous findings showing inhibitory effects of strangers on negative expressions in adults (e.g., Jakobs, Manstead, & Fisher, 2001). From a young age, humans learn to regulate their expressions depending on the social context. Zeman and Garber's (1996) study of children in grades one, three and five revealed that boys and girls reported controlling their expression of pain significantly more in the presence of peers than when they were with a parent or when they were alone. Children reported that their primary reason for controlling their pain expressions was the expectation of a negative interpersonal interaction following disclosure. In the present study, participants may have suppressed their expressions because of past experiences, personal or vicarious, with negative consequences following facial expression of pain. Historical and immediate social contextual factors influence adults' facial displays during pain. The results from the present study add to the growing body of literature highlighting the importance of considering facial expression of pain from a social communications perspective.

Having not asked participants about whether they deliberately moderated their facial expressions and not elucidating reasons for controlling pain expressions in those who did, we can only speculate as what factors motivated participants to deliberately modulate their expressions. One possibility is that participants were responding to a social display rule that specifies stoicism in response to nonthreatening pain. Participants may have also consciously (but not deliberately) or unconsciously altered their behaviour in response to such a display rule. More research is needed to specify social display rules for different pain contexts.

The inhibitory influence of the presence of strangers on facial expression during pain is unlikely to be static and would be expected to interact with other variables as people learn social skills throughout the lifespan. Facial expressions of pain at birth are best described as automatic and reflex-like and there is no evidence that the infant's initial expression in response to an eliciting pain stimulus is modulated (Izard & Malatesta, 1987). Control over expression progressively increases with age (Craig & Korol, in press). In studies of infants' reactions to immunization injections, Izard and colleagues observed decreases in the number of infants who showed pain and the amount of time they showed pain even within infancy (Izard, Hembree, Dougherty, & Spizzirri, 1983; Izard, Hembree, & Huebner, 1987). Of infants ranging from two to seven months of age, 91% uniformly displayed a pain expression immediately following needle penetration. In contrast, by 19 months of age, only 70% of infants displayed pain expressions. Izard (2002) suggests that differences emerge from the interplay of maturation of brain inhibitory systems on the one hand and socialization and cognitive development on the other.

As children grow older, they can self-manage involuntary expression to a certain extent rendering the link between pain experience and facial expression of pain less clear. Children as young as nine years old report moderating expression as a function of the audience present, with emotional responses displayed in front of other people less than when they are alone (Zeman & Garber, 1996). When instructed to do so, children aged eight to twelve years old were capable of controlling their facial expressions of pain to the extent that their suppressed pain expressions showed no differences from neutral expressions (Larochette, Chambers, & Craig, 2006). Thus, children are capable of controlling their pain expressions in response to at least some stimuli when instructed to do so. While facial expressions of pain are generally described as reflexive and involuntary at birth, as humans develop so does their capacity to regulate their facial expressions based on social display rules and motives.

As a potential challenge to the display rule explanation, no relationship between pain facial expressions and self-reported pain was observed in the experimenter absent condition, where facial expressions should have been the least affected by display rules. This finding can be interpreted in different ways. Ekman (1997) suggests that some display rules are so well established that people follow them even when they are alone. Response to a display rule may reflect an over-learned habit that operates automatically without the person being aware of managing the expression or considering voluntary movement (Ekman, 1997). In this case, participants would not likely be aware of trying to manage their expressions. Alternatively, response to a display rule may not be an automatic habit but an ideal to follow. In this case, participants would more likely be aware of trying to manage their expressions. Some people may imagine the reactions of others and then follow the appropriate display rule (Ekman, 1997). As well, there may be display rules that specify management of expression when alone (Ekman, 1997). Such a display rule may even specify that no management of expressions is needed when alone.

Correlations between facial activity level and self-reported pain were low in all conditions. They were not demonstrably different in subjects who participated alone, when facial expression was ostensibly the least social. However, this evidence is only speculative. Rosenberg and Ekman (1994) suggest that coherence between facial activity and emotional feelings may not be found if measures of facial activity are summarized over a period of time in order to make them comparable with single self-reports of emotional feelings. Generalized to pain, in the present study, we would not find coherence because facial activity was summarized and compared to single verbal self-reports. Accordingly, we maintain that the mechanism for social inhibition of facial expression in the present study could be display rules.

From an evolutionary perspective, the observed modulation of facial expression can be explained in terms of specialized cognitive propensities that generate functional facial expressions effective in the social world (Williams, 2002). Attempts to suppress pain expression can be understood as a function of the relationship between the person in pain and other people who are present. Evolved propensities toward social bonding allow us to express much behaviour in the presence of those who care for us compared to those who do not (Nelson & Panksepp, 1998). The present results are consistent with the proposition that it would be beneficial to suppress our expressions of pain in the presence of unfamiliar others unless we take them to be disposed to render aid (Green, 2002; Williams, 2002). Adaptive functions of facial displays of pain are expected to differ depending on whether the observers are strangers, family or social group members (Schmidt & Cohn, 2001; Williams 2002).

Our results showing less facial expression in the presence of experimenters who are strangers (low social bonding) are consistent with hypotheses derived from evolutionary theories and provide context for research showing an increase in pain behaviours in the presence of people who care for us such as parents and solicitous spouses (high social bonding). The present results provide a baseline for future studies by showing the potential impact of experimenters or other authoritative figures who are strangers.

Exposure to others' distress is aversive (Preston & de Waal, 2002) and recent studies show remarkable overlap between brain areas activated when a person undergoes painful sensory stimulation and when a person observes others suffering from pain (Botvinick et al., 2005; Saarela et al., 2007). Crombez and Eccleston (2002) suggest that a tendency toward suppression of pain expression in adults may arise because the desire to limit distress in others may be more adaptive than the expression of pain in adulthood. Given the powerful human need to belong and preserve social harmony through positive self-presentation (Baumeister & Leary, 1995), people may adjust their behaviour in order to be liked by others. In the present study, participants had control over the pain stimulus, knowing they could voluntarily withdraw from painful stimulation and the situation at any time, and experimenters were not in a position to help alleviate pain. Because participants did not need help from the experimenters they may have been more strongly influenced by ingratiation motives (Jones, 1964; Jones & Wortman, 1973) than pain management motives.

Social learning perspectives and evolutionary perspectives are not mutually exclusive. Indeed, the capacity to adapt to social demands leading to the usefulness of social display rules represents evolution of human cognitive and social flexibility. Perhaps the best explanation of the present findings combines the two approaches. Appreciation of display rules and social motives are reflected in efforts to maximize the adaptive response to specific situations. In its optimal form, this would involve articulate use of both language and nonverbal expression. In conformity to prevailing social standards and expectations, audiences could inhibit or facilitate reactions consistent with immediate demands. Panksepp and Smith Pasqualini (2002) argue that studies showing different effects of environmental contingencies such as social context on facial expression of pain do not provide evidence to choose between evolution and learning as explanations for regulation of pain expressions. Both are likely involved. The propensity to learn important social cues for regulation of expression may be a product of evolution without requiring specific directional rules for various environmental contingencies.

Audience Inhibition Effects: Voluntary or Spontaneous?

The face is a multi-signal system capable of producing involuntary and voluntary facial movements (Ekman, 1997). To what extent was the observed audience inhibition effect voluntary? The results do not answer this question. However, they add to the literature by showing that pain expression can be inhibited in situations other than those where people are told to control their expressions (e.g., Larochette, Chambers, & Craig, 2006; Prkachin, 2005). Voluntary and spontaneous expressions should be viewed on a continuum rather than viewed as two mutually exclusive extremes (Hess, Kappas, McHugo, Kleck, & Lanzetta, 1989; Hess & Kleck, 1990). Although facial expression can be influenced by social factors, modulation of facial actions does not necessarily imply either conscious control before or during the expression, or intentional signalling (Daly & Wilson, 1991). Naturally selected mental organizations that influence behaviour can be activated by information in the environment, whether or not the individual is consciously aware of this process. As well, social learning mechanisms can operate outside an individual's awareness. Experimenter social contexts can elicit modulation of pain expression. The degree to which this is done consciously remains to be established.

Facial Expression of Pain: Operational Definitions and Variability

A secondary goal of the present study was to add to the literature on the specificity and consistency of facial expressions during pain. In a recent critique of the research on facial expression of pain, Harris and Alvarado (2002) proposed that the most relevant data for evaluating the robustness of a proposed pain expression were frequency, percentages of subjects displaying each facial action, and co-occurrence of facial actions. To date, research on facial expression during pain still tends to focus on summary scores comprised of some combination of intensity and frequency scoring. While we do not criticize this approach, we advocate additionally examining the indices recommended by Harris and Alvarado. At the very least, examining the number of participants or patients displaying each action unit or configuration could facilitate interpretation of central tendencies in data. The data provided in this paper support the inclusion of this information and the potentially misleading effects of the absolute value of mean summary scores if such information is not provided. On the other hand, the need to examine individual action units and configurations is most important when issues of specificity arise. Sensitivity might be best satisfied by the composite indices. In studies of pain severity where pain is certain, perhaps only the aggregated measure is needed.

In the present study, considerable variability in facial movements during pain was observed. While the facial movements brow lower, orbital tighten, levator contraction and eye closure were prominent during cold pressor exposure, individual differences and between group differences were observed. During the pain observation periods, some participants frequently showed a prototypical pain face comprised of at least four overlapping pain-related actions, while other participants showed only one pain-related facial action and still others showed neutral faces during pain. Although the mild pain face prototype, moderate pain face prototype and individual facial actions that comprise those prototypes were observed more often during the cold pressor than before the cold pressor, they were observed in fewer participants and less frequently during the observation periods than expected.

Not all participants displayed all or even one of the four key facial actions (brow lower, orbital tighten, levator contraction and eye closure) described as prototypical (Williams, 2002) and shown to occur across different experimental pain stimuli (Prkachin, 1992). For example, when participants were alone and evidence of pain via facial expression was operationally defined as the cooccurrence of four facial movements, the prototypical moderate pain expression was observed in 17.5% of participants. Reducing the criterion for observation of a pain face to two facial actions (brow lower co-occurring with either orbital tightening or eyes closed), the prototypical mild pain expression was observed in 40% of participants. Applying an even looser operational definition of pain that required occurrence of at least one of the core four facial actions described as prototypical of pain (Prkachin, 1992; Williams, 2002), evidence of pain was observed in 77.5% of participants. The findings suggest that there are strict limits to inferences regarding underlying pain states based simply on measurements of facial activity.

Results from the present study can be compared to previous explorations of facial expression during pain. Consistent with the present results, substantial variability in the facial expressions of pain has been reported in the literature (Keefe, Bradley, & Crisson, 1990; LeResche & Dworkin, 1988; Patrick et al., 1986; Prkachin & Mercer, 1989). Craig and Patrick (1985) observed “rich individual variation” in the facial displays during pain. Although they identified groupings of facial actions that were prominent during cold pressor exposure, they reported that “by no means did all subjects display them”. Only one of their action unit categories (eyes closed and/or blink) occurred in all participants. However, blinking may have occurred in all participants regardless of pain. Unfortunately, the merged category is difficult to compare to the occurrence of eye closing in the present study. Craig and Patrick (1985) also provided data on the occurrence of upper lip raising, which they observed in 25% of participants. In the present study, upper lip raising was observed in a roughly comparable 19% of participants. Craig and Patrick (1985) did not report data regarding the number of participants who showed the other facial actions studied.

The present results can also be compared to a study examining a prototypical configuration of facial movements during pain. Although no published component studies of facial expression during pain have used the operational definition of mild pain prototype employed in the present study (brow lower overlapping with orbital tightening and/or eyes closed), LeResche and Dworkin (1988) examined a similar configuration. They operationalized the pain face as including an overlap of cheek raising (AU 6) or lids tightening (AU 7) with brow lowering (AU 4) and/or eyes closing (AU 43) or blinking (AU 45). They observed this pattern in all twenty-eight female patients with chronic temporomandibular disorder pain undergoing a painful clinical examination. If we had used these criteria in the present study, we would not have observed pain faces in all participants. The maximum number of participants who could have displayed this configuration during our observation periods was 29% of participants (we observed the necessary criteria of check raising or lid tightening in only 29% of participants). The differences between the results found by LeResche and Dworkin (1988) and the present study could be due to a variety of methodological differences including the nature of the painful stimulus (facial pain versus cold hand pain), context (specialty clinic versus laboratory), participants (chronic pain patients versus healthy student volunteers), pain severity (severe versus moderate) or motivation (relief of suffering versus participation credit).

It is also possible that the relatively low observation of facial actions typically associated with pain in the present study was related to the social context manipulation. If an evolved propensity or learned display rule for inhibition of expression was operating in the experimenter observing conditions, the facial expressions of participants may more closely resemble suppressed rather than genuine expressions. Hill and Craig (2002) observed that deliberately masked pain expressions did not differ from neutral baseline faces or spontaneous pain expressions for intensity, or duration of the facial actions they investigated (brow raise, brow lowering, orbital tightening, levator contraction, lip corner pull, dimpler, chin raise, tongue show, lip press, open mouth, eye slit, closed eyes, eye squint). With respect to frequency of the facial actions, they observed more mouth opening in the deliberately masked pain condition compared to the neutral condition; frequency of mouth opening did not differ between the genuine (spontaneous) and masked (deliberately suppressed) conditions. The general lack of differences between the neutral (no pain), genuine (spontaneous pain) and masked (deliberately suppressed pain) pain conditions suggest that the tendency for low observation or suppression of facial expressions of pain is not restricted to the present experimental context.

Interestingly, Craig and colleagues (1991) reported that the prototypical facial display of pain is not often observed when people are in genuine pain but is substantially more likely when people are faking pain. Hill and Craig (2002) observed greater intensity of brow raising, brow lowering, orbital tightening, and levator contraction and greater frequency of these variables plus mouth opening and eyes closing for faked pain compared to genuine pain. As well, the durations of faked brow lowering, orbital tightening, levator contraction, and closed eyes were longer for faked expressions than genuine pain expressions. Faked expressions of pain (or posed prototypical expressions of pain) appear to involve more frequent and intense facial activity of longer duration than genuine expressions in adults (Craig et al., 1991; Hyde, 1986) and children (Larochette et al., 2006). Low frequencies of prototypical facial actions associated with emotional expressions have also been described. If they occur, facial expressions of emotion seem to be more often partial than complete (e.g., Carroll & Russell, 1997; Reisenzein, 2000). If judges of other people's pain expect to see the type of expression they would pose if they were trying to approximate pain, they may underestimate the pain in people who show little facial movement during pain. The most common facial expressions of pain may be fleeting and incomplete compared to conceptual prototypes.

The low observation of prototypical facial actions during pain may be related to the measurement system we used. Puntillo et al. (2004) identified muscular rigidity as a key pain behaviour observed during common painful procedures. Poole and Craig (1992) suggested that patients who are suppressing pain might present an unusually static face. The facial action measurement system used in the present study, the FACS (Ekman et al., 2002) measures only *observable* facial movements. Increases in muscle tension may not have been observed. Further studies using different methods such as electromyography are warranted.

The low observation of prototypical pain facial actions during pain in the present study may have to do with the timing and qualities of the pain stimulus used. Inhibition of facial expression is not easy when an emotion begins abruptly and is strong (Ekman 1997). The same may be said of pain. Andrew (1975) described protective responses that occur in mammals and are evoked by startling and painful stimuli. The first phase of mammalian facial protective responses involves eye closure and orbicularis oculis contraction (causing brow lowering). As well, participants found it difficult to control contraction of the eye muscles at the outer canthus when a pain stimulus (cutaneous heat) reached a certain level and the experimenters used the facial movement as an indicator of the "pain-reaction end point" (Chapman & Jones, 1944). Prkachin and Mercer's (1989) Sequential Model of Pain Expression proposes that recruitment of the actions in the different phases depends on the severity and duration of the experience. In response to the immediate onset of severe pain or pain with intense emotional components, suppression may even be impossible.

Multiple observation periods were used in this experiment so the opportunity to capture expressions was as ample, if not greater, compared to other studies that have examined only one ten-second pain observation period (e.g., Hale & Hadjistavropoulos, 1997). While a display rule (e.g., inhibition of negative expression when no benefit of disclosure is perceived) may have influenced facial expressions, it may also be the case that examination of means of summary scores for facial expression variables in other studies has obscured previous observations of this phenomenon.

The low incidence of observation of facial actions typically associated with pain does not appear to reflect the absence of pain experience. The cold pressor task typically produced moderate levels of pain described as intense and very distressing with Short Form-McGill Questionnaire scores comparable to those for acute pain conditions such as post-surgical pain, angioplasty, and sheath removal, as well as chronic pain conditions, such as arthritis, and cancer pain (Turk & Melzack, 2001).

The relationship between pain experience and pain expression is complex. One only needs to introspect on his or her personal pain experiences to realize that the lack of correspondence between inner processes and outward behaviour is common. Despite this, a brief facial movement such as a wink or a wince can send a powerful message. The nature of spontaneous facial expressions appears to be fleeting. Most of the component facial actions associated with pain endure for less than 3 seconds (Prkachin, 1992), similar to expressions of emotions (Ekman, 1984). For communication purposes, the facial expression need not be constantly displayed and it would be advantageous to the person in pain to be able to control his or her expressions of pain.

The face is highly plastic and is used for verbal and nonverbal communicative functions unrelated to pain, as well as for eating, drinking, breathing and kissing, among other important functions. Facial expression during pain is highly variable and it is subject to the effects of intrapersonal, interpersonal and contextual factors. Pain is not always a sufficient condition for a corresponding prototypical facial expression. When facial expressions during pain do occur, they may convey information about pain or other classes of information such as (1) antecedents, events which brought about the expression; (2) a person's thoughts, plans, expectations, memories; (3) the internal physical state of the person showing the expression; 4) metaphor; 5) what an expresser is likely to do next; and 6) what an expresser wants a perceiver to do (Ekman, 1997). Interpretation of facial expression during pain as an accurate and complete reflection of inner pain experience using the operational definitions of facial expression used in this study should be avoided.

Although there is general agreement on the particular facial movements most reliably associated with pain, there is no consensus regarding the optimal way of combining the data from multiple facial movements. In the future, it would be helpful for researchers of facial expression during pain to report data not only on frequency, intensity and duration of individual facial actions or summary scores but also to include information on how many participants displayed particular actions or configurations.

Audience Effects on Facial Expressions of Emotion During Pain

Emotional qualities are a part of pain, as well as determinants and consequences of pain (Craig, 2005). The emotional quality of pain is emphasized in the International Association for the Study of Pain [IASP] definition of pain as a sensory *and emotional* experience. A lot of attention has been paid to the sensory aspects of pain but the emotional aspects have received less notice (Chapman, 2004; Price, 2000). In an effort to better understand the nature of pain experience and expression, as well as the relationship between the two, facial expressions of pain were examined in the context of facial expressions typically associated with emotional states. Harris and Alvarado (2002) suggested that the type of evidence required to support Williams' (2002) argument that natural selection shaped specific adaptations for the production and decoding of pain expressions would require that facial expression of pain be clear and distinct from emotional expressions. To this end, rather than examining facial expression of pain as a summary of action units that occur more often or in a greater intensity during pain than during baseline, we examined configurations of action units that prototypically are associated with pain and the basic emotions of sadness, fear, anger, disgust, surprise and happiness.

Disgust

Of the negative emotion facial expressions examined, the most commonly observed prototype was disgust. Disgust displays were observed less often before than during pain. During the pain phase, disgust expressions were shown more often when the experimenter was absent than when the experimenter was observing unseen or when the experimenter was present. Whether the presence of the experimenter was implicit (observing unseen) or explicit (observing seen) did not matter. Taken together, these findings suggest a social inhibition effect on disgust faces during pain. The pattern of results for disgust faces was similar to the social inhibition pattern found for pain faces.

The results from the present study can also be compared to two previous studies of facial expressions of emotion during pain. The present results converge with data from a study of facial expressions during a painful clinical exam in female patients with chronic temporomandibular disorder (LeResche & Dworkin, 1988). During acute pain stimulation, we observed disgust faces in 19% of participants whereas LeResche and Dworkin observed disgust faces in 21% of patients. LeResche and Dworkin presented no baseline data. However, baseline data were examined in a study measuring emotion facial expression prototypes during a venepuncture in patients with musculoskeletal pain conditions (Hale & Hadjistavropoulos, 1997). They observed that disgust faces occurred more often during pain than baseline; these findings converged with our data.

What is the link between facial expressions of pain and disgust? On a visual level, the prototypical patterns of facial expression for pain and disgust share some common elements. Nose wrinkling and upper lip raising are associated with both pain and disgust. When health care professionals were presented with photographs of prototypical facial expressions of pain and other emotions, pain was misidentified as disgust by 18% of professionals (Kappesser & Williams, 2002). Similarly, Keltner and Buswell (1996) found that 19.5% of participants misidentified pain as disgust. Although the similarities in the appearances of facial expressions typically associated with pain and disgust are important to consider, the reasons underlying the similarities remain to be elucidated.

Did participants find pain or some other aspect of the cold pressor disgusting? The association of pain with injury and disease may explain the observation of disgust expressions during pain. There is some evidence to suggest that disgust reactions to injections are prominent in individuals with blood-injection-injury phobia (Olatunji, Lohr, Sawchuk, & Patten, 2007). The observed facial expressions of disgust may reflect an inner experience of disgust. According to this interpretation, the reduced displays of disgust when the experimenter was present would mean that something about that condition was less disgusting. If the painful stimulus was indeed disgusting in some way, then we expect that the reduced display in the presence of the experimenter represented suppression of negative displays of emotion according to a display rule rather than an actual difference in experience.

It is also possible that the facial expressions observed in the present study reflected blends of emotion and pain expressions (Fridlund & Duchaine, 1996; Hale & Hadjistavropoulos, 1997; LeResche & Dworkin, 1988; Prkachin, 1997) or aspects of arousal and affective valence (Feldman Barrett & Russell, 1998) rather than mutually exclusive displays of prototypes. When facial expressions were ordered according to their affective valences, pain faces were perceived as the most unpleasant and disgust faces were perceived to be almost as unpleasant as pain faces (Feldman Barrett & Russell, 1998; Simon, Craig, Gosselin, Belin, & Rainville, 2007). Levator contraction, a common element of both pain and disgust faces, may reflect negative affect or an unpleasant aspect of the cold pressor experience. Participants may have displayed fewer disgust faces when an experimenter was present because audience presence changed the context so it was more pleasant. Alternatively, participants may have suppressed levator contraction in the presence of the experimenter in accordance with some display rule.

Displays of disgust during pain may have less to do with the personal experiential responses to the nature of the stimulus and more to do with the potential value to others and ourselves in the information conveyed by expressions of disgust. Conway and Schaller (2007) suggest that information bearing directly on basic human needs is especially likely to be judged as interpersonally relevant. Avoidance of harm and protection of kin from harm represent basic human needs (Conway & Schaller, 2007). Pain and disgust faces may signal immediate noxious events resulting in actual threat to the body's integrity and specific kinds of imminent threat such as those posed by poisons and communicable diseases (Curtis, Aunger, & Rabie, 2004; Rozin & Fallon, 1987; Wicker et al., 2003). Kappesser and Williams (2002) suggested that both facial expressions of pain and disgust convey the motivation to expel undesirable bodily experiences. Because pain can also be considered as clue to threat or harm, it follows that information about pain is interpersonally relevant. Therefore, we would expect pain-related, or threat-relevant, information, to be especially communicable. Perhaps, this type of information is also more likely to be suppressed in the presence of an antagonist or stranger so as not to provide a clue regarding threat, harm, or weakness to potential enemies.

To tease apart the different explanations in future studies, we would include measures of emotion other than facial expression, ask about different social motives, and use other means to examine display rules for emotions during pain in different contexts. For example, some studies simply ask people how they would behave in different social situations in an attempt to establish display rules (e.g., Zeman & Garber, 1996).

Anger

Does painful stimulation evoke facial expressions of anger? The present results add to the existing literature by showing that there are some situations in which prototypical expressions of anger will not be observed during pain. If we had used a sample of chronic pain patients or employed a less stringent operational definition of an anger face, we likely would have observed more anger faces. Using a less stringent operational definition of facial expression of anger, LeResche and Dworkin observed anger faces in 14% of chronic pain patients undergoing a painful medical exam. Hale and Hadjistavropoulos (1997) observed some anger faces (metric in study not clear) during venepuncture but did not observe any differences in anger expressions between baseline and pain.

The lack of observed anger expressions in the present study is understandable considering experimental acute pain stimulation over which participants have control over termination of the pain would not be expected to elicit the same emotional reactions or communications as a clinically-relevant acute pain exacerbation or superimposition of acute pain on chronic pain. Given research indicating that expressions of anger enhanced chances of being disliked (Clark, Pataki, & Carver, 1995), the low observations of anger expressions in the present study are not surprising. An ingratiation motive may have been more powerful in this experimental context than other motives typically associated with anger displays. For example, Izard (2002) proposed that it is adaptive to display anger during pain to signal protest against the aversive condition and marshal energy for defensive actions. Perhaps emphasizing the voluntary nature of participation to the experiment allayed any appraisals of the situation as coercive.

Sadness

Does painful stimulation evoke facial expressions of sadness? The present results add to the existing literature by showing that there are some situations in which prototypical expressions of sadness will not be observed during pain. If we had used a sample of chronic pain patients or employed a less stringent operational definition of a sad face, we likely would have observed more sad faces. Using a less stringent operational definition, LeResche and Dworkin observed sad expressions in 32% of female chronic pain patients undergoing a painful clinical exam. They did not report baseline data so we could not ascertain whether the expressions of sadness were related to aspects of the chronic pain situation or the acute pain exacerbation. Baseline data were collected in a study of patients with musculoskeletal pain conditions undergoing venepuncture. Although Hale and Hadjistavropoulos (1997) observed some expressions of sadness (metric in study not clear), no differences in sad expressions between baseline and venepuncture pain phases were observed.

The experimental context may account for the low incidences of sad expressions in the present study. Izard (2002) suggests that facial expressions of sadness are a stimulus for empathy and helping behaviour, although they can ultimately become aversive stimuli. Because participants in the present study did not require help (they could terminate the pain stimulus at any time) and may not have wanted to evoke empathy (aversive feeling) in the experimenter, it makes sense that no expressions of sadness were noted during the observation periods. Expressions of sadness also create an impression of dependence (Clark, Pataki, & Carver, 1995) and undergraduate students may not want to appear dependent.

Fear

Does painful stimulation evoke facial expressions of fear? The present results add to the existing literature by showing that there are some painful situations in which prototypical expressions of fear will not generally be observed. In the present study, the prototypical fear expression was observed in only one participant. This finding converges with the report that only one participant displayed facial expressions of fear in a study of chronic pain patients undergoing a painful clinical exam (LeResche & Dworkin, 1988). Given that people with high fear of pain probably would not have signed up for a pain experiment and that participants could withdraw from the cold pressor at any time, it is not surprising that few fear faces were observed in the present study.

Surprise

Very few facial expressions of surprise were observed during baseline or pain conditions. Interestingly, in eight experiments examining facial expressions of surprise in adults, Reisenzein, Bordgen, Holtbernd, and Matz (2006) found that although self-reports indicated the presence of surprise in most participants, the 3-component prototypical display of surprise was never observed. Using a less stringent operational definition consisting of eyebrow raising only, they observed facial expressions of surprise in 4% to 25% of participants. When considered in this context, it is surprising, that we observed any facial expressions of surprise, which we operationally defined as either one of two prototypical displays (1 + 2 + 5B + 26) or (1 + 2 + 5B + 27), which each consisted of four components. Compared to no observations of 3-component displays of surprise in eight studies specifically designed to elicit surprise expressions, we observed 4-component facial expressions of surprise in 3% of participants during pain. This result demonstrates the power of painful stimulation to elicit strong emotional reactions and facial expressions typically associated with emotions. The novel nature of the task (no participants had experienced the cold pressor before) and the immediacy with which the cold water can elicit moderate pain could have been surprising to participants. Inclusion of self-report ratings of emotions in future studies would facilitate interpretation of these findings.

Happiness

If you asked people to describe a prototypical pain face, smiling would probably not factor largely into their descriptions. In fact, in a study of health care workers' judgments of facial expressions (Kappesser & Williams, 2002), several participants remarked "someone who smiles cannot be in pain" (p. 204). LeResche and Dworkin (1988) specified the presence of lip corner pull (AU 12) as an exclusionary criterion for coding a pain face. However, lip corner pulling commonly occurs during pain and has been included as a variant of the prototypical expression in some conceptualizations (e.g., Williams, 2002). If smiling frequently occurs during pain and may confuse rather than strengthen a message regarding pain, what possible messages do smiles during pain convey? Furthermore, do different types of smiles convey dissimilar information? Several different types of smiles have been described in the literature. In the present study, we investigated three different types of smiles (felt, false, and miserable smiles). Different patterns were observed for occurrence of felt and false smiles during pain as a function of the social context. From the perspective of the Sociocommunications Model of Pain, the prevalence of smiling during pain and impact of smiling on pain assessment has relevance for ongoing social interactions and management of pain.

Felt smiles.

Happy expressions, also commonly referred to as felt smiles and Duchenne smiles, are defined as the cooccurrence of lip corner pulling and cheek raising. We also added the criteria of absence of brow lowering, lip corner depressor and chin raiser to differentiate felt smiles from miserable smiles. In the present study, across time periods, felt smiles were observed more frequently in the experimenter present group than the experimenter absent group or the experimenter observing unseen group. Overall, this pattern reflects a social facilitation effect dependent on the visual availability of the experimenter. In face-to-face interactions, participants showed more felt smiles during pain. The present finding concerning social facilitation of felt smiles is in line with evidence of social facilitation of smiling in response to negative emotional stimuli (Jakobs, Manstead, & Fischer, 2001; Schneider & Josephs, 1991; Yamamoto & Suzuki, 2006). While sociality influenced smile display, the meaning of the smiles is less clear.

Felt smiles are most commonly interpreted as emotional expressions of happiness (Ekman & Friesen, 1982) or motive-communications indicating a readiness for affiliation (Fridlund, 1994). With respect to the interpretation that the felt smiles represented increases in happiness, it is possible that those participants who were undergoing painful stimulation in the presence of an experimenter were happier than participants in the other groups and that they were happier during the cold pressor phase than baseline. Perhaps participants were happy to be succeeding in the task of keeping their hand submerged in the cold water and found it to be a more positive situation than the baseline waiting period. Perhaps participants enjoyed the company of an experimenter more during the painful stimulation than during the baseline period.

Alternatively, smiling during pain may represent a more interpersonally relevant signal. For example, Fridlund (1991)'s interpretation of felt smiles as indicating a readiness to affiliate makes sense within the context of the experiment. In psychology, affiliation is generally described as the need to form attachments to other people for support, guidance, and protection (Schachter, 1959). Schacter demonstrated that anxiety increases the tendency to affiliate in many contexts. It may be that pain also increases the tendency to affiliate in some contexts.

The term affiliation stems from the Latin ad-filiare, to adopt as a son, and, understood in this light, an affiliation attempt might reflect an effort to turn a stranger into a friend or kin-substitute. Strangers represent unknown social entities. Furthermore, a stranger need not remain unknown. Strangers can turn into friends or enemies. In the present experiment, participants may have decreased pain expression in the presence of a potential enemy but increased smiling in the presence of a potential friend.

Harris and Alvarado (2002) suggest that lip corner pulling may represent an attempt at help-seeking through ingratiation. They also suggest that smiling during pain may have emerged as a way of keeping rough and tumble play from becoming dangerous. Consistent with an affiliation motive, participants' smiles may suggest that they were attempting to recruit smiles from the experimenter. The finding that participants smiled more when they could actually receive some feedback from the experimenter (experimenter present condition) as compared to when they knew an observer was present but could not see the experimenters face supports this notion of an affiliation attempt.

It is also possible that the occurrence of felt smiles during pain may reflect an artifactual association. Cheek raising, the key criterion for felt smiles, is one of the core features of pain expressions. Lip corner pulling is also frequently associated with pain. Lip corner pulling during pain may relate to a spontaneous or deliberate masking effort, with some evidence of pain (orbital tightening) leaking through. Future research could delineate the different possibilities by gathering verbal-self report data on emotions such as happiness and social motives such as the desire to show the experimenter they were friendly.

False smiles.

While felt smiles are described as spontaneously occurring and relatively more difficult to voluntarily produce, false smiles are described as deliberate attempts to appear as if positive emotion were felt when it is not or to send a duplicitous social message. In contrast to the findings for felt smiles, the differences in false smiles shown as a function of audience condition was moderated by the experimental phase examined. For the experimenter absent group, false smiles were observed more often during the baseline phase compared to the pain phase. In contrast, for the experimenter observing unseen group, significantly fewer false smiles were observed during the baseline phase compared to the pain phase. Finally, in the experimenter present group, no reliable differences in the display of false smiles were observed between baseline and pain. Visual inspection of the data revealed similar mean scores for the baseline and pain phases in the experimenter present group as in the baseline phase for the experimenter absent group and the pain phase for the experimenter observing unseen group.

This pattern of results is difficult to interpret. While the observation of false smiles during the experimenter observing unseen and experimenter present conditions is consistent with descriptions of false smiling as an impression-management or self-presentation skill, it is not clear why false smiles during the baseline period in the experimenter absent group would have been observed. The false smile has been described as an appeasement signal (Fridlund, 1994) and it is possible that it was automatically elicited as a response to a potentially threatening or anxiety-provoking situation (anticipating an unknown pain stimulus). An alternative explanation is that participants in the audience absent condition felt as though they were being observed. However, if this were the case, we would have expected to see a similar amount of smiling in the experimenter observing unseen condition. We observed no false smiling during the baseline condition so we think the first interpretation is more likely.

False smiles during pain may reflect an effort to conceal pain experience. Lip corner pull (AU 12), an essential component of smiling is the most common *mask*, an action unit used to conceal an emotional expression (Ekman, Friesen & Hagar, 2002). Presumably, smiles could also be used to conceal a pain expression. There may be social benefits to its display. For example, Prkachin and Silverman (2002) suggested that restricted use of false smiles might reflect limited use of appeasement, contributing to uncomfortable interpersonal relations and limited social support. Given research indicating that expressions of happiness evoked an impression of likeability (Clark, Pataki, & Carver, 1995), it is not surprising that people would regulate their facial expressions depending on the context. Exposure to others' distress is aversive (Preston & de Waal, 2002) and pain sufferers show concern for the distress that behavioural expressions of their pain may cause to other people (Dar et al., 1992). In this way, smiles during pain may reflect a motive to maintain social harmony.

Miserable smiles.

The saying "grin and bear" it is commonly used as a direction toward coping with pain and may reflect a common display rule. This saying does not imply that one has to enjoy the pain nor does it imply that one must in some way try to reduce the pain. When we think of people grinning and bearing their pain, we might think of someone smiling but also revealing evidence that they are miserable. Miserable smiles are generally described as acknowledgements of feeling miserable but not intending to change the situation (Ekman & Friesen, 1982). In contrast to our expectation that miserable smiles may be the most frequently observed type of smile during this experiment, miserable smiles were not observed at all during baseline and were observed in five participants during the cold pressor. Because fewer than five percent of participants displayed miserable smiles, they were not subjected to further statistical analysis.

Smiles in the pain literature.

The observation of smiles during pain may at first seem counterintuitive because pain is emotionally unpleasant in nature and we tend to associate smiles with pleasant expressions of happiness (Feldman Barrett & Russell, 1998). However, numerous other potential meanings of and reasons for smiling exist as outlined above. With respect to future studies of facial expressions during pain, what should be done with observations of smiling? Should they be incorporated into operational definitions of facial expressions of pain that sum facial action units or require cooccurrence? Should smiles be examined separately? Based on the data from the current study, we conclude that smiles should be examined separately. Furthermore, distinguishing between different types of smiles would be useful to researchers interested in emotions, social context, and functions of pain expression.

Further Reflections on Facial Expressions of Emotion During Pain

Very few detailed, component studies of facial expressions of emotion during pain have been conducted. The studies that have been conducted used different methodologies making integration of their findings somewhat difficult. A number of general explanations concerning the discrepancies that have been observed are evident in the current study and the broader literature.

The observed discrepancies for facial expressions of sadness and anger may relate to different operational definitions of the particular facial expressions used in the studies. LeResche and Dworkin (1988) based their operational definitions on EMFACS Dictionary and Coders' Guide (Ekman & Friesen, 1985) whereas we based our operational definitions on the prototypes in The Investigator's Guide to FACS (Ekman, Friesen, & Hagar, 2002), which supersedes the earlier work as it has a more substantial evidence base. Prototypes based on the latter criteria (Ekman, Friesen, & Hagar, 2002) were chosen because they contain the most central or most common actions for each emotion, have the best evidence for universality, are more specific than the combinations in the EMFACS coding scheme (Ekman & Friesen, 1985) and reduced the likelihood of confusion with pain-related actions. In addition to measurement differences, the discrepancy between findings may also be accounted for by the differences in the type of pain stimulus (experimental versus clinical), participants (healthy volunteers versus chronic pain patients), and context (lab versus clinic).

The present findings must be interpreted within the context of relatively low observation rates. There were individual differences among participants with respect to their facial expressions. For those who displayed various facial expression prototypes, the meaning of these expressions is still a question of debate (Fridlund, 1991; 1994). They may reflect inner experiences, convey social motives, serve as signals, among other functions, or represent various combinations of any of these.

So what can the findings from the present study tell us about the link between facial expressions of pain and emotion? The results confirm the involvement of emotion (in some capacity) in the expression of pain. Izard (2002) suggested that pain and each of the basic emotions are separate modular systems that can function with some independence (Izard, 2002; LeDoux, 1996). Facial expressions associated with disgust and happiness may be basic to facial expression in immediate response to acute pain, at least in this situation. We have speculated as to why display and detection of these facial expressions during pain may be functional. A pattern of pain and basic emotion expressions in response to injury provides an adaptive advantage over a pain expression alone (Izard, 2002).

Experimenter Audience Condition and Cold Immersion Time

Cold immersion time was not influenced by the social differences among audience conditions, did not significantly account for unique variance in facial expression of pain, and did not did not emerge as a mediator variable between audience condition and facial expression of pain.

The results of this experiment can be compared to other studies examining the influence of social factors on cold immersion time. The results converged with studies that found no differences in cold pressor tolerance related to maternal efforts to promote coping with the painful cold (Chambers, Craig, & Bennett, 2002) or peer audience presence (Badali, 2000). The results diverged from other studies that found effects of social factors on cold immersion time. For example, social modelling has been shown to affect pain endurance with exposure to pain tolerant models increasing pain tolerance times and exposure to pain intolerant models decreasing pain tolerance times (Craig & Weiss, 1971; Symbaluk, Heth, Cameron, & Pierce, 1997). Experimenter status can also influence cold immersion time with participants tested by a higher status experimenter (e.g., university professor) showing higher pain tolerance compared to those tested by a lower status experimenter (e.g., the research assistant) (Campbell, Holder, France, 2006; Kállai, Barke, & Voss, 2004).

There are a number of apparent reasons why no differences among groups in cold immersion time emerged in the present study. The experimental manipulation of audience sociality may not have had potent effects on cold immersion time because participants knew that their cold immersion time was being measured. For the purposes of task performances, the salience of the experimenter, who was measuring cold immersion time regardless of presence or absence in the room during the cold pressor, may have led to higher cold immersion times overall. Studies show that cold immersion times reflect robust individual differences in pain tolerance (Chen, Dworkin, Haug, & Gehrig, 1989), which may explain why social factors did not account for variability in the responses. Other individual differences or social contextual variables may have been in operation.

The differences in the literature may reflect variations in methodology such as the instructions and temperature (Hirsch & Liebert, 1998). The large proportion of participants in the present study who reached the ceiling cold immersion time suggests that there were factors in operation that may have led to reduced variability in times. There may have been a ceiling effect with the specified time period of three minutes. As well, specification of the goal can lead to increased pain tolerance times (Stevenson, Kanfer, & Higgins, 1984) as can identification of the cold pressor as a nonthreatening stimulus (Jackson, Pope, Nagasaka, Fritch, Iezzi, & Chen, 2005). Recommendations for the standardized administration of the cold pressor task in children have been articulated (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005) and publication of standardized guidelines would also be useful in the adult literature.

Experimenter Audience Condition and Heart Rate

Changes in heart rate were not influenced by the social differences among audience conditions. Heart rate change also did not emerge as a mediator variable between audience condition and facial expression of pain. Changes in heart rate are generally not apparent to another person and so are not considered to be communication signals in the same way as observable verbal and nonverbal behaviours. Accordingly, the visual availability of another person to whom an impression may be made would be expected to be less important.

The results of this experiment can be compared to other studies examining the influence of social factors on heart rate changes during pain. The results converge with studies that found no differences in heart rate during pain as a result of psychosocial factors such as maternal interaction (e.g., Chambers, Craig, & Bennett, 2002) and experimenter sex (Aslaksen, Myrbakk, Høifødt, Flaten, 2006). The results diverge from studies that found social modelling influences on heart rate during pain (Craig & Prkachin, 1978). The differences in the literature may reflect the varied intrapersonal, interpersonal and contextual factors in the studies.

The inconsistent results may be explained by the differential potency of various forms of social influence. Social modelling is one type of social influence and may be expected to be more powerful than audience effects. For example, Craig and Prkachin (1978) used multiple exposures and careful shaping of change, which may be considered a more potent form of social modelling than a simple exposure. Social modelling is a powerful form of social influence on pain behaviour (Craig, 1987) and a fundamental mechanism of intergenerational cultural transmission (Bandura, 1977). Within the realm of audience effects, the sociality of different audience conditions can be considered on a continuum to the extent that they suppose the presence of other people (Hess, Banse, & Kappas, 1995). An alone situation represents the least social condition. In contrast, a situation with several audience members with whom the subject has a close personal relationship (family, friends) represents a more social condition because as audiences, family and friends are expected to elicit different responses than strangers or enemies (Schmidt & Cohn, 2001; Williams, 2002).

Although heart rate change was not reliably influenced by different audience conditions, it accounted for variance in the likelihood of facial expression of pain. As change in heart rate increased, likelihood of observing a pain face increased. Several possible explanations for the observed pattern exist. For example, larger increases in heart rate could cause increases in facial expression of pain. Alternatively, larger increases in heart rate could be caused by increases in facial expression of pain. It is also possible that other unknown factors could cause direct increases in both heart rate and facial expression or could mediate and/or moderate the relationship between heart rate and facial expression. Finally, the result may be statistically significant but not clinically relevant, with no meaningful relationship between heart rate and facial expression.

Although larger increases in heart rate could cause increases in facial expression of pain, no evidence for this explanation exists. This hypothesis could be tested in future studies by manipulating heart rate through an arousing but not painful test (e.g., physical exercise or difficult math problems) compared to a resting period, and then comparing facial expressions of high versus low heart rate groups in response to painful stimuli.

There is more evidence to support the explanation that larger increases in heart rate could be caused by increases in facial expression of pain. Some research suggests that modulations in behaviour can instigate parallel changes in associated subjective and autonomic components (Izard, 1971; Laird, 1974; Lanzetta, Cartwright-Smith, & Kleck, 1976). Positive relationships among facial activity and physiological response are predicted by the facial-feedback hypothesis. The facial feedback hypothesis (Buck, 1980) suggests that the control of facial expression produces parallel effects on subjective and internal states. Lanzetta et al. (1976) found that subjective and physiological measures were higher when participants voluntarily exaggerated and lower when they voluntarily inhibited facial reactions in response to painful electric shock. Kleck et al. (1976) and Colby et al. (1977) reported similar effects. A more recent partial test of the facial feedback theory in pain did not support it (Prkachin 2005) with respect to self-reports. Prkachin (2005) found that instructions to exaggerate or inhibit pain expression had no effect on participants' subjective reports of pain. No measure of autonomic activity was included. Results from the present study do not fully support the facial-feedback hypothesis. In the present study, although participants who showed prototypical facial expressions of pain showed a greater change in heart rate, they did not self-report a stronger subjective experience of pain. Further research testing the facial feedback hypothesis in pain is needed.

Another explanation for a potential influence of facial expressions on heart rate concerns expectations. Facial expressions reflect the individual's social learning history surrounding pain expressions as well as the immediate social context (Craig, 1986). A past history of negative consequences surrounding pain expressions may have increased arousal when facial expressions were displayed. Current expectations may also have been a factor. These explanations would be consistent with the existence of a display rule suggesting that pain expression should generally be suppressed.

The increases in both heart rate change and facial expression of pain observed in the present study could also be explained by other variables (e.g., catastrophizing) that were not examined in the present study. Individual differences in facial expression (Izard, 2002; Harris & Alvarado, 2002) and in heart rate responses (Colloca, Benedetti, & Pollo, 2006) during pain have been observed and can be reliably reproduced. Finally, it is possible that no meaningful relationship between heart rate and facial expression exists. The meaning of the changes in heart rate is ambiguous. While onset of acute pain is generally associated with changes in heart rate (Terkelsen, Mølgaard, Hansen, Andersen, & Jensen, 2005), heart rate changes are not specific to pain. Heart rate appears to be related to many psychological states including emotions and is also considered a general index of arousal.

Retrospective Verbal Self-reports of Pain

When we are alone, we simply are in pain. We do not have to try to describe it or manage our expressions. When we are with other people, we may be motivated to provide verbal descriptions of our experience to others. Sometimes, we may find that verbal language is adequate for our purposes. Other times, we may struggle with trying to find the right words to convey our experience. Even when the right words are available, various factors may influence motivation to accurately represent the experience. Despite the limits of self-reports, both people in pain and caregivers frequently rely on retrospective verbal self-reports to convey and understand pain experiences.

No reliable differences among audience groups with respect to retrospective verbal self-reports of pain severity, sensory intensity, and affective unpleasantness were observed. As well, verbal self-reports of pain did not emerge as a mediator between audience condition and facial expression of pain. It is important to note that self-reports were *not* provided while the different audience conditions were in effect. All self-reports were provided in the *presence* of an experimenter. Differences among groups were expected to be related to differences in pain experience during the cold pressor rather than pain expression during reporting. However, no differences were observed. It is unclear whether the self-reports reflected pain experience during the cold pressor or expressions of what participants perceived should be reported in the presence of the experimenter, among other possibilities. Using self-reports as a measure of experience, the pattern of findings suggests that observed differences in facial expression reflected the impact of social factors directly on the expression of pain rather than indirectly influencing the expression of pain by changing experience first.

The results of the present study do *not* imply that self-reports are not influenced by audience conditions. Self-reports are generally considered to be more easily influenced by social variables and individual motives than nonverbal measures, which can be relatively more automatic and reflexive in origins (Craig & Hadjistavropoulos, 2002). Differences in self-report pain ratings may have emerged if the self-reports were provided in the same audience contexts as the pain stimulus and facial expression recording. For example, Kleck and colleagues (1976) observed lower self-reports of pain in a group observed through a one-way mirror compared to unobserved groups. In contrast, Sullivan and colleagues (2004) reported no main effects of observer condition (present versus absent) on self-reports of pain during cold water immersion. The study methodologies differ from each other in that self-report ratings were provided following electric shock in the research by Kleck and colleagues and in the Sullivan et al. investigation self-report ratings were provided at regular intervals during the cold pressor stimulation.

The extent to which the retrospective self-reports of pain collected in the present study are an accurate indicator of the pain experience is unclear. Self-reports are themselves pain expressions. Also, the retrospective nature of the reports complicated the comparability of self-reports to the other behavioural responses during pain. However, retrospective self-reports of pain are relevant because clinicians rely on them heavily during examinations of pain patients. Future research would benefit from examining multiple measures under the same conditions.

The likelihood of facial expression of pain was better predicted by social context (experimenter absence versus implicit or explicit presence) than by verbal-self reports of pain. These findings confirm the importance of context in interpretation of facial expressions during pain.

Judges' Ratings

The complexities of assessing pain in another person necessitate sensitivity to their behaviour, including facial expression. Attention to the experiences of others when they confront stimuli that evoke pain has importance for personal and group survival (Goubert et al., 2005) as well as social harmony. In situations outside of the laboratory, witnessing another person expressing pain could lead to wide ranging reactions. For example, observers may be concerned about their personal safety and feel afraid. Observers may also be concerned about the other person and want to help (Goubert et al., 2005). In the safety of a laboratory context, we would expect judges not to be concerned about personal safety. On the other hand, because they are judging videotapes of strangers, we would not expect them to be as concerned for the other person as if they were interacting in person with family or friends. Because the participants (encoders of pain) and the judges (decoders of pain) in this experiment were construed as interacting with strangers, the likelihood both of participants suppressing their facial expressions of pain and judges' underestimating pain based on information from facial expressions may be increased.

The descriptive topography of facial activity (what the face is doing) can differ from judges' attributions of subjective pain state based on facial activity (what the face is communicating about pain). Social perception of others' facial actions entails imposing meaning upon the objective events. Accordingly, in addition to examining facial activity using FACS, judges' attributions were examined. Judges' ratings of participants' pain and expressiveness differed as a function of audience condition. Judge' ratings of pain and expressiveness were higher for the experimenter absent group compared to the experimenter observing unseen group and the experimenter present group. No reliable difference between the latter two groups was observed.

In the present study, the pattern of judges' ratings converged with the FACS data showing a pattern of socially inhibited pain and disgust faces as well as socially facilitated happy faces. Patterns of increased happy faces as well as decreased pain and disgust faces in the presence of an experimenter may have been perceived by the judges and interpreted as less pain experience. However, the differences among audience groups are more likely to reflect differences in pain expression rather than pain experience. The patterns observed for retrospective self-reports of pain, cold immersion times, and heart rate, where no differences between groups were observed, support this interpretation. Taken together, these findings indicate that the sociality of the context during participants' experience of pain, though it did not influence retrospective self-reports of the experience, cold immersion times, or heart rate changes, manifested itself in changes in observable behaviour during the experience to the extent that judges naïve to the social context manipulation in this experiment rated pain and expressiveness, on average, differently as a result.

The potential clinical implications of differences in patient nonverbal behaviour were explored by comparing participants' self-reports of pain to judges' ratings of pain based on nonverbal cues. Participants' described more pain (e.g., mean response corresponded to "moderate pain" descriptor) than judges' assessed (e.g., mean response corresponded to "mild pain" descriptor). Audience condition significantly influenced discrepancies between self-reports and judges' ratings of pain. Differences between self-reports and judges' ratings for the experimenter absent group were smaller than for the experimenter present group. No other comparisons between groups were reliable. The relationship between audience condition and the discrepancies between self-reports and judges' ratings was at least partially mediated by participant facial expression.

Potential clinical implications of discrepancies between self-reports of pain and judges' ratings of pain based on nonverbal cues were explored by having judges make hypothetical assessments regarding whether pain management was warranted for each participant. Judges assessed the experimenter absent group as warranting pain relief to a greater extent than the experimenter present group. In contrast, no reliable differences in pain management assessments were observed between the experimenter absent group and the experimenter observing unseen group or between the experimenter observing unseen group and the experimenter present group. This pattern mirrors the pattern of results for discrepancies between self-report and judges' pain ratings. It appears that there are situational influences on facial expressiveness during pain that are detectable by naïve observers and that these differences could influence pain management decisions.

Differences in facial displays related to factors other than pain stimulation such as audience effects can impact judgments based on nonverbal cues. Nonverbal cues can influence caregivers responsible for pain management decisions (Fordyce, 1976; Prkachin, Currie, & Craig, 1983; Prkachin & Craig, 1985); Hadjistavropoulos, Ross, & von Baeyer, 1990). Furthermore, when provided with multiple sources of information, observers often attach greater credibility to non-verbal expressions than they do to verbal report (Craig, 1992) and patients who express pain non-verbally are more likely to be viewed as suffering compared to patients who do not (Craig, Prkachin, & Grunau, 2001). There was a positive relationship between facial expression of pain as coded by FACS and judges' ratings of pain, but social factors as simple as experimenter presence influenced both measurements. Therefore, social factors that may lead to inhibition or suppression of facial expression of pain must be elucidated and such factors considered when making pain judgments. If not, a trend toward greater underestimation of pain and accuracies may continue.

The general pattern of underestimation of pain on the part of judges is consistent with the general underestimation bias reported in the literature (Choiniere, Melzack, Girard, Rondeau, Paquin, 1990; Teske, Daut, & Cleeland, 1983; Zalon, 1993). For example, Prkachin, Berzins and Mercer (1994) observed that student judges of patients with shoulder pain were likely to downgrade the intensity of patients' suffering to the extent that observers' pain estimates were systematically lower than the patients' estimates by fifty to eighty percent.

The pronounced tendency of judges to underestimate pain when they have access only to facial cues is relevant for interpretation of the results. Judges' ratings likely were biased to reflect an unnatural reliance on facial expression cues because they were only presented with facial expression and cold immersion time stimuli. Kappesser, Williams, and Prkachin (2006) found that health care professionals' judgments of patients' pain varied depending on the cues given. In particular, judges viewing the face without patients' self-report ratings underestimated pain to a greater extent than judges provided with patients' self-report ratings.

Other potential missing cues were a pain stimulus that was familiar to judges' and a pain context that was more likely to evoke empathy. The discrepancy between participants' self-reports and judges' ratings may not have been as large if they had better knowledge of the pain stimulus. Robinson and Wise (2004) found that experiencing the cold pressor before watching videos increased accuracy of estimating others' pain. Empathy from the judges may not have been evoked by the videotaped images of participants' in pain because judges were aware that the participants were volunteers who could withdraw at any time rather than individuals suffering from real health problems or undergoing medical procedures. Observers without experience may underestimate others' pain unless observers are endowed with sufficient empathy (Danziger, Prkachin, & Willer, 2006). From a social communications perspective, when the observer has no meaningful or ongoing relationship with the person in pain (no social transaction occurring as it would in real life judgment contexts) – no past experience, no current knowledge or intended future – information provided by the expression may not be as precise.

The tendency to underestimate pain based on access to only one type of pain expression (e.g., facial expressions only) (Kappesser, Williams, & Prkachin, 2006) may also be related to cultural decoding rules. Cultural decoding rules are culturally prescribed rules for managing the perception and interpretation of others' expressions that are learned early in life (Matsumoto & Ekman, 1989). Matsumoto (1989) found that cultures that encourage and maintain power and status differences among members and encourage more collectivistic orientations perceived less intensity in expressions of anger, fear, and sadness so as not to disrupt group harmony or status relationships. Although pain was not examined, it is possible that expressions of pain may be deamplified or neutralized in a similar manner. Matsumoto, Kasri, and Kooken (1999) suggest that a relationship may exist between rules governing expressive behaviour (display rules) and rules governing perception and interpretation (decoding rules). It is possible that the same cultural expectations (e.g., "maintain status quo" or "do not disrupt group harmony") that lead participants to show fewer facial expressions of pain in the presence of others may also lead judges to lower their interpretation of pain. In the present study, display rules could have contributed to the differences in judges' ratings between audience groups and decoding rules could have contributed to the general pain underestimation on the part of judges.

It is important to note that observers' judgments are indirect, inferential, and potentially biased. Relatively little is known about the specific mechanisms and process involved in the integration of information and formation of judgments about pain (Hadjistavropoulos, Craig & Fuchs-Lacelle, 2004). Future research on the communication process, including judgment processes, is merited. Research examining behavioural tendencies (e.g., toward helping) and ideas of individualistic versus collectivistic cultures are some areas of future interest. Also, further research on the nature of decoding rules and, how and why they are related to differences in judgments of pain is needed. Accurate pain assessment is essential for effective pain treatment. Underestimating pain in others carries the risk of the person in pain receiving inadequate care and feeling misunderstood, or in some cases, made to feel as though they were attempting to deceive others in order to obtain some gain.

Relationships Among Pain Self-reports, Facial Expression, and Judges' Ratings

Whether a person is sending or receiving a message regarding pain and its context, inclusion of different versions of that message may be a source of confusion or clarification. Information about pain from verbal-self reports and facial expression may help clarify a message if they are consistent. If the information conflicts, this may make the task of pain communication even more difficult.

In the present study, despite both measures of pain expression (verbal self-reports and facial expressions) generally being positively related to judges' ratings, the two measures were not related to each other. Examination of relationships between variables broken down by audience condition revealed that social factors such as who was present during pain expression could influence the relationship between variables. For example, the relationship between judges' ratings and facial expression appeared weaker when the experimenter was present compared to when the experimenter was absent or observing unseen. The positive correlations were considered medium in magnitude for the experimenter present group and large in magnitude for the experimenter absent and observing unseen groups (Cohen, 1988). Overall, the results add to the growing body of literature that reveals discordance between measures and the different conditions that may account for the divergent results in the literature (Hadjistavropoulos et al., 1998; LeResche & Dworkin, 1988; Prkachin, 1992).

Studies have varied in whether verbal self-reports of pain, facial expressions of pain, and pain judgments were related. Some researchers found no association among measures (e.g., Hadjistavropoulos et al., 1998; Hadjistavropoulos et al, 2002; LeResche & Dworkin, 1988; Prkachin, 1992). Other researchers observed significant positive correlations among measures (e.g., Patrick, Craig, & Prkachin, 1986). In a meta-analysis of the relationship between self-reports of pain intensity and direct observations of pain behaviour in 29 studies, estimation of the overall effect size yielded a moderately positive association (Labus, Keefe, & Jensen, 2003). However, high variability across studies was observed. Self-reports of pain intensity and direct observations of pain behaviour are more likely to be significantly related to each other when the individual being studied has acute pain, when the self-report of pain intensity data are collected soon after the observation of pain behaviour, when global composite measures are used to quantify pain behaviour, and when the observed person suffers from chronic low back pain (Labus, Keefe, & Jensen, 2003).

Generally, all measures of pain are limited in their ability to independently provide a comprehensive evaluation of an individual's subjective, individualized pain experience. This research highlights the importance of including multiple measures of pain expression, including self-reports and facial expressions, in the process of examining outward criteria in order to access inner pain processes. This research also points to the possible influence of social factors on pain expression and, subsequently, judgments.

The results of the present study confirm the importance of examining pain from a social communications perspective and examining different sources of information about pain available. According to the Sociocommunications Model of Pain, there are distinctions between pain experience, pain expression, pain assessment, and pain management. As pain experience is only accessible to others through pain expression, a good deal of inference is involved. It is unsurprising that measures of pain expression and judgment may not always be related.

Exploration of Moderating Variables

Self-monitoring Orientation

Communication of pain can be influenced by impression-management motives. To the extent that people are sensitive to and concerned with the kinds of impressions that others form about them, they would be expected to attempt to manipulate interpersonal interactions to encourage positive impression formation in others. Inclusion of a measure of self-monitoring facilitated exploration of the possibility that participants consciously manipulated their facial expressions when they thought they were being observed in order to achieve positive impression-management goals. Individual differences in self-monitoring orientation, the extent to which individuals strategically cultivate public appearances (Gangestad & Snyder, 2000; Snyder, 1974; Snyder & Gangestad, 1986), accounted for unique variance in facial expression during pain. The prediction of likelihood of showing a pain face using self-monitoring scores, although statistically significant, was small. In contrast to our expectation that people with low self-monitoring scores would be more likely to show a pain face, a public expression consistent with their inner experience, the opposite result was found. People with higher self-monitoring scores were more likely to display prototypical displays of pain. It could be that high self-monitors were generally more expressive, as self-monitoring scores are often considered as measures of expressive tendencies. Hence, a general tendency towards higher expressiveness on the part of high self-monitors may have resulted in more facial expression during pain. Alternatively, a general tendency toward more impression management of situation cues may have led to a display of pain. In this way, high-self monitors may have responded to cues that nonverbal display of pain was desirable or consistent with pain experience.

The contribution of self-monitoring orientation to facial expression during pain as measured by prototypical facial displays of pain has not been explored previously in published studies. However, these results can be loosely compared to a study that examined the influence of self-monitoring on pain responses generally. The present study's results diverge from prior research indicating no differences in pain responses related to self-monitoring orientation found by Kleck et al. (1976). However, the methodologies of the studies differ. Kleck et al (1976) studied only males, used a phasic pain stimulus (shock), and did not employ detailed component methods of coding facial expression. Further research is needed to tease apart whether it is a tendency towards greater expressiveness or a greater effort to cultivate public appearances in response to demand characteristics on the part of individuals characterized as high in self-monitoring orientation that contributed to the differences in facial display of pain.

To the extent that facial expressions during pain were consciously controlled in accordance with social display rules, and assuming that a social display rule prescribing attenuation or inhibition of pain was activated in the presence of an experimenter, we would expect that the relationship between experimenter audience conditions and facial expressions during pain would be moderated by the extent to which individuals engage in positive self-presentation. Exploratory analyses did not reveal any moderating effect of self-monitoring on the relationship between audience conditions and facial expressions of pain, disgust or smiles. If self-presentation were the key variable underlying the observed audience effects on facial expression, we would have expected self-monitors to be especially prone to this bias. Specifically, we would have expected to see larger differences in expression between high self-monitors and low-self-monitors in the more social experimenter present condition, which would be expected to elicit self-presentation motives, compared to the less social experimenter absent condition. No moderating role of self-monitoring orientation as an individual differences variable was observed. These results suggest that the differences in facial expressions as a function of audience condition may be better understood as spontaneously modulated rather than voluntarily controlled in an effort to respond to situational demands with a positive self-presentation. Indeed, Jones and Pittman (1982) suggest that the goal of impression management is more likely to be attained when this goal remains beneath the surface. This suggestion is supported by the lack of observation of the most reliable facial actions associated with pain in the majority of participants in the present study compared to the results from other studies indicating that participants who are explicitly instructed to suppress their pain leak some evidence of pain.

Regardless of the mechanisms underlying self-presentation motives and corresponding behavioural changes, there are potential hidden costs to use of general positive impression-management strategies in the context of pain situations. For example, masking facial expressions of pain with a smile in order to appear likable may backfire for patients in healthcare settings, where they may be perceived as coping well or not suffering. Kappesser and Williams (2004) anecdotally reported that several health care workers in their judgments study remarked that smiling contraindicates pain. If this belief is prevalent among health care workers, then pain could be underestimated in individuals attempting to present themselves in a positive manner. To the extent that observers can perceive both clues to pain and attempts toward positive self-management, the best balance may be struck regarding maintaining harmony in interpersonal interactions and obtaining help.

Sex

> *Are there sex differences in pain? Ask the opinion of almost anyone and the answer will usually be yes (McCaffery &Ferrell, 1992; Bendelow, 1993). In fact, when carefully reviewed, evidence can be found for sex differences in virtually every sensory realm (Velle, 1987). Consensus disappears, however, on what the differences are."*
>
> *Berkley, 1997, p. 371.*

Communication of pain among men and women may differ as a result of sex differences in reproductive organs, compositional and temporal features of sex hormones (Berkley, 1997), as well as differences in socialization of males and females. Although the literature on human pain responses is brimming with evidence of sex differences, there is little evidence showing sex differences in immediate facial expressions in response to acute pain stimuli. For various reasons, investigators have restricted some investigations only to females (Craig & Patrick, LeResche & Dworkin, 1988; LeResche, Dworkin, Wilson, & Ehrlich, 1992; Wang, 2005) or males (Kleck et al, 1976). Other investigator included both males and females in their samples but did not compare them (Hale & Hadjistavropoulos, 1997). A methodological barrier to examination of sex differences stems from the time-consuming nature of coding facial expression using FACS, which limits sample size. In order to properly examine sex differences, double the sample size is required. The findings from the few studies investigating sex differences in facial expression during pain are mixed.

In the present study, none of participant sex, experimenter sex, or the interaction between the two predicted the likelihood of participants showing a prototypical mild pain face during the cold pressor task. No other published studies examined the effects of experimenter sex on facial expressions during pain. However, studies comparing facial expressions of males and females during pain have been conducted. The present results are consistent with results from studies of healthy young adults who reported no sex differences in facial responses of participants during painful shock, cold, pressure, ischemia (Prkachin, 1992; Prkachin, 2005) or tonic heat stimulation (Kunz, Gruber, & Lautenbacher, 2006). The results also converge with results indicating no sex difference in facial expressions of pain in infants less than one year old (Fuller, 2002). In contrast, the present null findings diverge from studies indicating differences between male and female newborns. Recently born female neonates of all gestational ages expressed more facial features of pain than male infants during a capillary puncture (Guinsburg et al., 2000). As well, male neonates showed a shorter time to display facial actions following heel-lance than female neonates (Grunau & Craig, 1987).

Results from the present study can be compared to the growing body of literature examining general sex differences in pain expression. The lack of experimenter sex effects and experimenter-participant sex interactions for facial expressions of pain, heart rate, cold immersion time and self-reports of pain are consistent with studies reporting no sex differences in pain thresholds (Kállai et al., 2004; Otto & Dougher, 1985), tolerances (Otto & Dougher, 1985; Weisse, Foster, & Fisher, 2005), nociceptive discrimination (Feine, Bushnell, Miron, & Duncan, 1991), self-reported pain unpleasantness (Aslaksen et al., 2007; Weisse et al., 2005), self-reported pain intensity (Feine, Bushnell, Miron, & Duncan, 1991; Weisse et al., 2005), or stress, mood, heart rate variability, and skin conductance (Aslaksen et al., 2007).

The lack of experimenter sex effects and experimenter-participant sex interactions diverges from studies showing experimenter sex can affect participant sex differences in pain estimates, especially when experimenters are attractive and dressed to accentuate their sexuality (Levine & DeSimone, 1991). Others have also observed interactions between participant sex and experimenter sex on pain intensity (Aslaksen et al., 2007), arousal during pain (Aslaksen et al., 2007), average pain threshold (Gijsbers & Nicholson, 2005) and pain tolerance (Kállai et al. (2004).

The observed lack of sex differences in facial expressions of pain did not provide support for the hypothesis, based on evolutionary theory, that males would be more likely to attempt to hide facial expressions of pain than females (Voracek & Shackelford, 2002), particularly in the presence of strangers. The observed lack of sex differences in facial expression of pain also did not support the hypothesis, based on social learning of display rules, that males were less likely to express pain than females in public (Zeman & Garber, 1996). However, the evidence from the present study does not necessarily contradict these theories. In social settings based outside the laboratory, sex differences may be more relevant. As well, differences in facial expressions examined over a longer period of time or during chronic pain may be more revealing. In the context of evolutionary theory, we might expect immediate responses to onset of pain to vary less than facial expressions during later recovery phases of acute pain or during chronic pain. On the other hand, the present findings may be in line with inductive analysis of existing data that demonstrate more similarities than differences in pain experience between females and males (Berkley, 1997).

The relationship between sex, gender, and pain as well as the impact of sex and roles of persons in the external environment is complex. In an integrative review, Berkley (1997) concluded that even under rigidly controlled experimental circumstances, the presence and direction of sex differences in pain reports are influenced by situational, health, pain stimulus properties as well as hormonal, motivational, and nutritional factors. The lack of sex effects found in the present study must be interpreted with caution as sex effects may have been observed if the dependent variable facial expression of pain were operationalized differently or other contextual factors were varied. Additionally, a larger sample size would have improved the power for the interaction analyses. Overall, the results from the present study contribute to a complex literature on sex differences.

Visible Minority Status

The exploratory analysis of the contribution of experimenter-participant concordance with respect to visible minority status or simply of participant visible minority status did not reveal any differences in facial expression in pain. However, ethnicity is a complex topic that is perhaps better conceptualized in terms of acculturation (Ryder, Alden, & Paulhus, 2000) rather than simply broken down into labelled categories based on country of birth origin. The participants in the present study were more similar than different in other aspects. For example, all participants were university undergraduate students. The null findings should not be interpreted as representing a lack of impact of sociocultural factors on pain in other situations, as these are well established. There are cultural, environmental, and racial variations in pain experience and pain expression (Bonham, 2001; Edwards, Doleys, Fillingim, & Lowery, 2001; Edwards, Fillingim, & Keefe, 2001; LeResche, 2001; Linton, 2004; Rollman, 2004).

Individual Experimenters

Analyses revealed no differences in the effects of individual experimenters on any of the dependent measures. This was not surprising because experimenters followed a script and all wore white lab coats to provide some consistency. Researchers use scripts and double-blind methodologies in an effort to prevent such influences. However, a study examining the blinding effectiveness and association of pretreatment expectations with pain improvement in a double-blind randomized controlled trial suggests that fully double-blind conditions are very difficult to achieve (Turner, Jensen, Warms, & Cardenas, 2002). Individual characteristics of experimenters may influence pain behaviour in other settings and should be considered as potential influences.

Suspiciousness

Analyses revealed that participants' are generally suspicious of psychology experiments. For at least some participants, the experimenter absent condition may have been experienced similarly to the experimenter observing unseen group. The experimenter absent condition does not represent an asocial context in which participants' behaviour can be considered to reflect behaviour in an unobserved setting. However, the experimenter observing unseen group was purposely included in this study so that this possibility could be explored. Consideration of sociality and participant awareness of being observed is important for any study where deceptive procedures are utilized.

Implications of Findings

Research Implications

Researchers could benefit from considering the potential social influence of the experimenters in studies of pain. The present research shows that experimenters can be considered as social interactants in experiments. The findings imply that it is important to elucidate experimenter variables in research studies. It is common to report sample sizes and basic demographic characteristics of participants. It is also important to at least describe such variables as they relate to experimenters and preferable to attempt to control for experimenter variables (e.g., randomize participants to experimenters).

Although these results contribute to the body of research indicating that pain is associated with a characteristic facial display, they also suggest that this association is far from perfect. The present results have some practical implications for future facial expression research. In order to increase the comparability of results among studies, we suggest that the number of participants showing each facial action typically associated with pain and showing particular combinations of actions be routinely reported.

Applied Implications

Clinicians could benefit from considering the potential impact of social factors on facial expressions of pain. Effective pain assessment is a vital step toward providing appropriate pain management for people who are suffering. Facial expressions commonly factor into the pain assessment process. For example, when reflecting on their judgments of infant pain, parents identified facial expressions as the most important cue to pain in infants aged 4, 6 12 and 18 months (Pillai Riddell, Badali, & Craig, 2004). Facial expressions are also used as cues to judge adult patients capable of verbal language. In a study of the process of postoperative pain assessment, nurses relied most frequently on criteria related to the patient's appearance and drew on their past experience in terms of what physical signs to look for (e.g., facial expressions, bodily movement, and heart rate) (Kim, Schwartz-Barcott, Tracy, Fortin, & Sjöström, 2005). Results from the present study suggest that in adults, patients' facial expressions can be considered as more than signs of pain and may reflect sensitivity to the social context.

Facial displays have been characterized as more involuntary and less susceptible to social influences when compared to self-reports, which have been criticized for susceptibility to setting demand characteristics and reporting biases (Craig, 1992; Craig, Prkachin, & Grunau 2001; Hadjistavropoulos & Craig, 2002). The present results do not dispute these arguments but they do demonstrate that nonverbal expression can also be influenced by basic social factors.

While measures of facial actions are useful tools to augment our understanding of pain in other people, it would be unwise to rely on them too heavily in an adult population. Specific pain faces would appear more likely during onset of acute pain or exacerbation of chronic pain than for chronic pain or pain during recovery of healing phases of injury. A one-to-one relationship between pain experience and pain expression does not exist. Among different modalities of pain communication (i.e., facial expression and verbal self-reports) considerable variation occurs. The congruity between pain experience and expression, and the specific and sensitive information available from expression, may vary across individuals, groups and, as the present study demonstrated, situations.

To the extent that they use facial expression as a clue to pain, clinicians should be aware of the potential inhibiting effect of the presence of strangers on facial expression. While clinicians are in a position to provide care, they are also strangers. Facial displays of pain produced in the clinical context may be spontaneously suppressed and represent a response typically given to strangers rather than an expression typically given to potentially sympathetic care providers who are within the person's social group (Schmidt 2002). The tendency to suppress facial expression of pain in the presence of helpful caregivers who are also strangers may reflect an evolved propensity for self-protection from strangers that would have been adaptive in our evolutionary history but is no longer helpful today. Although facial expressions can also represent a learned communication tool, it may be that there are some genetic constraints of facial expression that could lead to a reduction in attribution of pain and caregivers' helpful responses in health care settings. There is a risk of underestimation and undermanagement as a consequence.

Overall, the results support the proposition (Williams, 2002) that the increases in pain behaviours shown by children in the presence of parents during medical procedures (Gonzalez et al., 1989; Gross, Stern, Levin, Dale, & Wojnilower, 1983; Shaw & Routh, 1982; Vervoort et al.,

2008) and shown by chronic pain patients in the presence of solicitous spouses (Block et al., 1980; Flor et al., 1995) may reflect true expressions of pain or a release of suppression of pain rather than intensification or exaggeration of pain. Interpretation of the results using the former framework may lead to less underestimation of pain in other people, which can contribute to improving the serious clinical problem of uncontrolled pain.

Limitations

Design and Internal Validity

Sociality

The complex construct of sociality attempts to capture features of the rich and varied social arrangements governing the lives of humans. While one key dimension of sociality, audience effects, was manipulated in the experiment, other social factors were not examined. Each participant entered the experiment with a rich history of social experiences that could have influenced their pain experience and expression in the experiment. The randomized design was implemented to control for individual differences. The observed differences between the condition where participants were alone in the testing room and the condition where participants were being observed through a one-way mirror indicated that the experimental manipulation was, at least, partially successful in approximating conditions that differed in sociality. However, the high ratings of suspiciousness of being watched reported by some participants in the experimenter absent group indicated that the experimenter absent group did not fully approximate a true alone group. This is consistent with research conducted by Fridlund and colleagues demonstrating imaginary audience effects (1990).

People appear to invent social arrangements or conceptualize themselves as in social settings even when alone. Participants could have been thinking about anyone or anything during the cold pressor task. Observation of more facial expressions of pain in the audience absent group may have been related to the fact that participants pictured a friendly interactant in their head, among other possibilities deserving exploration. The internal validity of the present study could have been better understood if we had asked participants about the exact nature of social audiences they potentially were imagining. The impossibility of a true alone condition, as a baseline for the comparison of results from other sociality conditions, limits empirical conclusions that can be drawn from attempts to study spontaneous, non-socially mediated expression.

It is noteworthy that any attempt to study phenomenological experience using obtrusive measures would likely have the impact of introducing elements of sociality into the subjective experience of participants. Accordingly, it is difficult to imagine how other researchers would succeed in achieving more than our partially successful effort to approximating the conditions of a true alone or unobserved state. Although we can hypothesize the direction of the display rule (more facial expression of pain when participants are alone) in this particular experimental context, we cannot be as sure about the magnitude of the difference between conditions. It could be that if we were able to better capture the spirit of being alone and unobserved, we might have seen more dramatic differences between groups. On the other hand, differences were observed in the judges' ratings suggesting that the differences in facial expressions were substantial enough to influence bystanders.

Suspiciousness

Another limit to the internal validity of the study was the suspicion that many undergraduate students expressed about psychology researchers use of deception in experiments and specific aspects of the setting. Suspiciousness by undergraduate participants in psychology experiments is commonplace (Taylor & Shepperd, 1996). It was our intention that the experimenter should be perceived as a neutral interactant but participants who were high in suspiciousness may have been more likely to perceive the experimenter as a deceptive source, possibly arousing hostility or reducing feelings of trust towards the experimenter. If this were the case, we would have expected reduced facial expression of pain in suspicious participants; however, suspiciousness did not predict facial expression.

Experimenter Behaviour

Another limit to the study is related to experimenter behaviour. Although experimenters were trained to maintain neutral faces throughout the course of the cold pressor task and verbally followed a written script for the rest of the experiment, it is possible that vocal or nonverbal characteristics may have influenced the results. The experimenters' faces were not actually recorded during the experiment so this manipulation check is missing. It is possible that the experimenters occasionally failed to maintain a perfectly neutral face.

External Validity and Generalizability

Although we found consistent evidence that the presence of an experimenter, explicit or implicit, had an impact on facial expression associated with cold pressor pain experienced by healthy students in a laboratory, these results may not generalize to other participant samples (e.g., chronic pain patients, people of different ages and ethnicities), experimenters, pain stimuli, settings, or judges.

Experimenters

Conclusions about the influence of an experimenter audience on pain response may not generalize to all experimenters. For example, the role and status of the observer in the situation relative to the encoder are important variables (Kállai et al., 2004). Caution also should be exercised in concluding that the presence or absence of any observer would have a comparable impact. For example, friends would be expected to have a different impact than enemies. Level of kinship between the person in pain and the observer may also be relevant. In the present study, an effort was made to hold possible confounds constant (e.g., all experimenters wore white lab coats and introduced themselves as research assistants), balance their effects (e.g., an equal number of female and male experimenters tested an equal number of female and male participants in each group), or randomize the effects (e.g., ethnicity).

Pain Stimulus

Procedures used in the present study may also limit generalizability. Firstly, although the ability of the cold pressor to stimulate pain in humans has been well demonstrated (Chen et al., 1989), experimental pain paradigms are not socially equivalent to acute or chronic pain that occurs in complex environments. The cold pressor would not be associated with the same degree of threat that typically accompanies the pain of injury or illness in the natural environment. Participants in the present experiment knew the origin and expected duration of their pain. They were informed that no permanent harm would result from the stimulus and that they could withdraw from painful stimulation at any time. In this way, the cold pressor may not elicit the same cognitive (e.g., catastrophic thoughts such as 'I'm going to die'), emotional (e.g., fear) and motivational (e.g., need to withdraw from painful stimulus) components of pain experienced in a natural setting.

Our clear explanation to participants that the maximal stimulus duration would be three minutes might have led to increased pain tolerance. Thorn and Williams (1989) who found that subjects given specific time goals on an acute pain task demonstrated increased pain tolerance and lower pain ratings. Unfortunately, these researchers offered no predictions regarding the effect upon facial expression, which was our primary variable of interest. While understanding of pain origins, duration, and appropriate actions to take varies in natural, clinical, and laboratory settings and could influence pain experience, expression, and action differentially, the primary purpose of this experiment was to examine a between-groups comparison, so it would be expected that such effects would be held constant across groups.

Setting

While the setting may be generalizable to other experimental pain laboratory contexts, it does not extend to all contexts in which pain is experienced. For example, the present experimental context is one of non-threat and high control, which is more similar to a person engaging in a voluntary painful procedure (e.g., blood donation) rather than acute or chronic pain with unknown or known but uncontrollable cause in the natural environment. Nonetheless, these results highlight the variance in pain communication, even in innocuous situations where communication is not vital for survival. While the present experiment is an artificial approximation of nonlaboratory settings, the lab context does reflect a genuine and relevant social context with its own set of demand characteristics and social display rules in operation. The participant-experimenter context shares features of other social situations such as doctor-patient contexts and parent-child relationships (Orne, 1962)

Judges

Caution must be exercised before generalizing the judgment results from the sample used in the present study to other populations of judges. The present study used a small, relatively homogeneous sample of untrained student judges. Rosenthal (1987) describes various judge characteristics that could influence sensitivity to nonverbal cues. These characteristics include occupation, sex, cognitive complexity, volunteering, achievement potential, social-religious values, interpersonal adequacy, democratic orientation, maturity, interpersonal sensitivity, and task orientation.

Analyses and Statistical Power

The planned statistical analyses could not all be carried out. Some major violations in the assumptions of certain tests led to use of alternative tests. The relatively low incidence of facial expressions associated with pain led to reduced variability, with the bulk of participants showing no prototypical pain expressions when strict cooccurrence criteria for a moderate pain face were applied. Even when the less stringent cooccurrence criteria for a mild pain face were applied, the bulk of participants showed no prototypical pain expressions. Although it was possible to examine the effects of audience on the frequency of facial expressions of pain, it was not feasible to explore the influence of variables thought to moderate or mediate the magnitude of the effect size of change in facial expression as a result of the audience manipulation because there were so many 'no pain face' observations. The alternative binary approach (pain face versus no pain face) adopted rendered the data analyzable but the dichotomization of the pain expression variable and use of cooccurrence criteria rather than simply adopting a summative approach may have resulted in decreased sensitivity to pain in favour of specificity of pain expression. We would have used a larger sample if we had anticipated so few 'no pain' facial expressions during pain. However, the alternative statistical procedures were utilized.

Measurement

Difficulties with the measurement of facial expression of pain using FACS were encountered. The initial operational definition of facial expression of pain and measurement strategies planned (requiring cooccurrence of brow lower, tightening and closing of the eye lids and nose wrinkling/upper lip raising during any of the observed periods), although specific, were not adequately sensitive to pain stimulation. Even though the strategy ultimately adopted, requiring cooccurrence of brow lower and orbital tightening or eye closing represents a more specific approach than the summary approaches typically used in published studies, this conceptualization still lacks in specificity.

Both brow lowering and orbital tightening are component actions of various emotional expression prototypes. The occurrence of these actions during pain may reflect the emotional component of pain or occurrence of various emotions, which were not measured via self-report. For example, the mild pain face criteria could also represent minimum negative affect criteria, as the individual components are frequently associated with anger. Alternatively, they may reflect a nonspecific state neither associated with pain or an emotional state, such as attention or concentration.

Another concern with the approach adopted was that it was not optimally sensitive to detecting the presence of pain. It is possible that there were subtle movements made by participants that were undetectable by FACS. While the use of more sensitive techniques such as facial electromyography would have been useful, it is hard to use these techniques and not draw attention to facial movement. It may be argued that movements that are unobservable by others are not as relevant to studies of facial communication of pain. The summary approaches used regularly in the field would be more sensitive and in clinical contexts when pain is known these approaches are probably better.

Although the measure of facial expression of pain utilized in the present study does not have adequate psychometric properties to be endorsed as a clinical tool (e.g., too many false negatives), it did reveal differences between groups with respect to audience sociality. All the possible approaches to measuring facial expression explored by the author revealed the same pattern of results with respect to the effects of audience sociality on facial expression.

Future Directions

Failure to consider social context, including who is present, when assessing pain could lead to inaccurate perceptions of the person in pain (false negatives and false positives), which may result in a number of undesirable consequences including unnecessary suffering and medical complications, as well as fear and distrust of health care providers (Ross, Bush, & Crummette, 1991). Consequently, examining how the presence of different audiences (e.g., age, attractiveness, gender, status, ethnicity, relationship to the individual in pain) may influence or interact with patient variables to influence pain expression could lead to improved care for suffering individuals. Future directions will include manipulations of social conditions where the audience manipulation will more directly test the idea that potential caregiving status (caregiver versus noncaregiver audience) in contexts where care is needed will influence pain behaviour. For example, an audience who has the ability to reduce the participant's pain (e.g., terminate the stimulus) or help them in some way may have a different impact than neutral observers or observers who could be considered threatening in some way. The publication of basic statistics such as the percentage of people who displayed each facial action may be used as a basis for comparison across studies.

Future laboratory studies are also planned to follow up this dissertation. The next study planned is a thought experiment. A survey methodology will be used to collect information about undergraduate students' beliefs regarding whether experimenters influence participants' pain responses in experiments and, if so, to elucidate what factors students think are influential and to what degree. This study will include a specific section describing this thesis experiment and asking participants to predict how they thought their pain behaviours might be affected by the experimenter manipulation and how they thought the average undergraduate student's behaviours might be affected by the experimenter manipulation. In this way, students' self-reported predictions about their behaviour and others' behaviour (in essence, their normative display rules) can be compared to the results from this study.

A follow-up study assessing judgment accuracy is also planned. Baseline segments and pain segments will be selected from the videoclips and judges will view them in a random order. Judges will select from a preset list of prototypical facial expression labels, which will include neutral face and pain face, but will also include emotion labels (e.g., sadness, fear, surprise, happiness, disgust and surprise) and other state labels (e.g., concentration, interest). Judges' confidence in their ratings will also be assessed.

Further examination of moderators and mediators of the effects of sociality on facial expression during pain is needed. After the data for this study were collected, a study by Sullivan et al. (2004) was published indicating the potential importance of catastrophizing as a moderating variable of the effects of observation on facial expression. Other intrapersonal variables such as hostility may be relevant. In order to tease apart the impact of emotion on facial expression, measures of emotion will be collected along with measures of pain in future studies. In particular, we are interested in examining whether the occurrence of felt smiling during pain is related to verbal self-report ratings of happiness.

We are also interested in examining social inhibition effects on facial expression of pain in other contexts and teasing out the variables in the present study that may have contributed to the relatively low incidence of observation of facial actions associated with pain. For example, the communication conditions under which facial expressions during pain are observed and verbal self-reports are provided merits further investigation. Sullivan et al. (2006) found that participants with musculoskeletal pain conditions displayed more facial grimaces when asked to rate their pain while lifting objects than when they estimated the weight of the object (Sullivan et al., 2006). Participants in the present study may have displayed more facial expressions of pain if they were asked to provide self-reports of their pain simultaneously rather than retrospectively. The difference between facial expressions concurrent with self-reports versus facial expressions in absence of self-reports is of considerable interest. Further investigation of this topic may reveal why the incidence of facial expression during pain appeared to be so low in the current study.

The question still remains how best to interpret and weigh the information available from different facial actions associated with pain. How many facial actions are required to quantify the pain signal? Does an expression need to contain more than one pain-related actions? If so, do these actions need to be specific to pain rather than also being important components in emotional expressions? If an expression has more than a certain number of facial actions, is the information from those movements redundant or unique? These questions have important implications and while a fuzzy set of actions associated with the facial expression of pain has been identified and prototypes examined, the scaling of pain expressions and relation to various aspects of multidimensional pain experience remains to be clarified.

Conclusion

The idea that a person's internal pain processes can be inferred from close inspection of outward criteria such as facial movements and body gestures has intuitive appeal. If we could accurately and reliably know another person's pain by outward manifestations, we would be in a better position to help them or help ourselves by avoiding pain-provoking stimuli or harming the other person to gain an advantage. While there is some evidence that nonverbal signals provide accurate information about pain experience, there are situations that may provoke suppression of pain expression on the part of the person in pain, making the task of discerning pain more complex.

Whether modulation of facial movements during pain serves to express inner experience, regulate inner experience, influence others in the social environment, or is due to a combination of factors, it appears that the modulation of facial movements during pain occurs. The likelihood and extent of inhibition of facial expressions during pain likely depends on the population, pain characteristics, personality dimensions, gender, culture and context, among other factors. In the case of the present study, with a moderately painful stimulus in a nonthreatening, experimental environment, it appears that healthy young adult students inhibit facial movements typically associated with pain when an experimenter is watching. However, it would be overzealous to take our laboratory findings as a basis for making direct predictions about facial expression in general. Rather the results provide a reference point for more complex examinations of social factors and pain behaviour.

The Sociocommunications Model of Pain incorporates contextual influences and can provide a basis for interventions aimed at improving health care providers' assessment and management of pain. Explication of the variables that influence the encoding and decoding of pain has implications for biopsychosocial theories of pain as well as current clinical practice. In the future, the information gleaned from this project may be used to extend the current focus on biological parameters of pain to incorporate psychological and social parameters, to provide further details of the encoding level of processing in the Sociocommunications Model of Pain, and to improve pain assessment and management techniques.

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APPENDIX I

Copy of UBC Research Ethics Board's Certificate of Approval

The University of British Columbia
Office of Research Services and Administration
Behavioural Research Ethics Board

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	Number
Craig, K.D.	Psychology	B99-0501

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT
UBC Campus ,
CO-INVESTIGATORS:
Badali, Melanie, Psychology
SPONSORING AGENCIES
Social Sciences & Humanities Research Council

Communicating Pain Encoding and Decoding Processes (III)

APPROVAL DATE	TERM (YEARS)	AMENDMENT:	AMENDMENT APPROVED:
JAN 27 2000	1		

CERTIFICATION:

The protocol describing the above-named project has been reviewed by the Committee and the experimental procedures were found to be acceptable on ethical grounds for research involving human subjects.

[redacted]

Approval of the Behavioural Research Ethics Board by one of:
Dr. I. Franks, Associate Chair
Dr. R. Johnston, Associate Chair
Dr. R. D.Spratley, Director, Research Services

This Certificate of Approval is valid for the above term provided there is no change in the experimental procedures