SOCIAL MODELING INFLUENCES ON SELF-REPORT AND FACIAL EXPRESSION INDICES OF COLD-INDUCED PAIN

BY

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ABSTRACT

Socialization has been identified as one important source of individual differences in pain expression (Craig, 1980). Previous laboratory studies (e.g. Craig, 1978a; Craig & Coren, 1975; Craig & Prkachin, 1978) had shown that self-report, physiological, and psychophysical indices of electric shock-induced pain could be influenced by social modeling. The present study attempted to replicate these findings using a different noxious stimulus, the cold pressor test, and two separate indices of the pain experience - self-report and facial expression.

Subjects (72 female introductory psychology students, ages 17 to 25 years) undertook the cold pressor test and rated their discomfort in the presence of either a tolerant, an intolerant, or an inactive model. Half the subjects in each of these three groups were permitted to see both the model and the model's ratings of discomfort (visual condition); the other half were screened from the model, and saw only the model's discomfort ratings (nonvisual condition). Subjects' facial expressions were videotaped during the cold pressor test and subsequently scored using the Facial Action Coding System (Ekman & Friesen, 1978b). It was hypothesized that subjects exposed to a tolerant model would report less pain, endure the cold pressor for a longer period of time, and show fewer facial signs of pain than control group subjects; intolerant-modeling subjects were expected to show more distress on both self-report and facial measures. Moreover, modeling group differences in facial expression were expected to be more pronounced in the visual condition.

The results indicated that only self-report indices of pain were influenced by the modeling manipulation, even in the visual condition. However, further analyses suggested that facial indices of pain do not covary with self-report, even amongst control subjects; facial signs of distress were most prominent at the onset of noxious stimulation, although self-reported discomfort increased over exposure time.

The results were discussed in light of past research on cold-induced pain (e.g. Wolf & Hardy, 1941). Also, facial actions associated with pain in the present study were contrasted with earlier descriptions of the pain expression (Hjortsjo, 1969). Finally, a discussion was made of implications for future research.

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Introduction and Literature Review

Socialization has been identified as one important source of individual differences in pain expression (Craig, 1980). There is evidence that the development of pain expression and experience involves a shift from innate response patterns released by noxious stimulation to more complex reactions including cognitive, affective, and behavioral components (Izard et al., 1980; Levy, 1960). The impact of social modeling of pain experience appears to be one variable which contributes to this shift (Craig, 1978b, 1980). Crosscultural studies (e.g. Zborowski, 1969) and case histories of clinical pain patients (e.g. Christensen & Mortensen, 1975; Shoben & Borland, 1954) have suggested that parents, siblings, and significant others serve as models for the experience of pain and the manner in which it is expressed.

Laboratory studies have shown that self-report and other indices of the experience of pain can be affected by social modeling. Craig and his colleagues (e.g. Craig, 1978a; Craig, Best & Best, 1978) demonstrated that self-reported pain was lower for subjects who witnessed a tolerant model during noxious stimulation than for subjects who witnessed an intolerant model or an inactive peer. Other studies (e.g. Craig & Coren, 1975; Craig, Best, & Ward, 1975; Craig & Prkachin, 1978) have provided evidence that physiological and psychophysical indices of the pain experience are subject to the same modeling manipulation.

The Craig et al. studies have typically involved exposing pairs of individuals to an ascending series of electric shocks at the same time. The participants are told that the experiment is examining people's reactions to electrical stimulation of increasing intensity and they are asked to provide ratings of distress on a categorical, verbal, or visual analogue rating scale after each shock is delivered. Only one of the participants, however, is a "real" subject - the other is actually a confederate trained to assume either a tolerant or an intolerant role relative to the subject. In the tolerant condition, the confederate (whose shock electrode is nonfunctional) provides consistently lower self-reports of discomfort than the subject over the ascending shock series; in the intolerant condition, the confederate provides consistently higher self-reports of discomfort. It has generally been found that subjects participating with a tolerant model will accept more intense shocks, and rate the stimuli as less painful, than subjects receiving shocks alone or in the presence of an inactive confederate. The effect of an intolerant model has tended to be less consistent: In some studies (e.g. Craig, Best, & Best, 1978; Craig, Best, & Ward, 1975), intolerant-modeling subjects accepted less shock and reported more pain than tolerant-modeling subjects, but were not significantly less tolerant than controls. In other studies (e.g. Craig & Coren, 1975; Craig & Weiss, 1971), intolerant-modeling subjects were significantly less tolerant than either tolerant-modeling subjects or controls. One explanation for these discrepent findings is that intolerant/control group differences may in some cases be obviated by a "floor" effect: control subjects may show intolerance that cannot reasonably be surpassed.

The results of these studies have been interpreted as evidence that social modeling can affect one's experience of pain, and that social modeling may be an important determinant of individual pain expression in the real world (Craig, 1978a, 1978b). However, various issues need to be resolved before these findings can justifiably be applied to non-laboratory settings.

One methodological limitation of the aforementioned studies is their use of idiosyncratic, unstandardized rating scales for measuring self-reported distress. Although simple visual analogue scales may be of some merit (Reading, 1980), they are psychometrically limited and difficult to compare across studies (Gracely, 1979). Moreover, when used to measure the experience of pain, they tend to assess it as if it were a simple sensation varying only in intensity. Considerable evidence exists, however, to support the notion that pain is a qualitatively varied experience involving cognitive and affective as well as sensory components (Beecher, 1959; Melzack, 1973; Melzack & Casey, 1968; Sternbach, 1968). Recent research (e.g. Crockett, Prkachin, & Craig, 1977; Leavitt, Garron, Whisler, & Sheinkop, 1978) has suggested, in fact, that assessing these components independently may provide us with different kinds of information: Affective - evaluative descriptors provide information about pain magnitude and qualities whereas sensory descriptors provide more diagnostic information.

Fortunately, recent developments in ratio-scaling techniques have led to the construction of sophisticated self-report devices which enable one to independently assess different components of the pain experience. Gracely, McGrath, and Dubner (1978a, 1978b) have used cross-modality matching to develop ratio scales for affective and sensory dimensions of pain, and have provided evidence for their reliability and validity: Mean scale values tend to be reliable within individual subjects (mean $\underline{r}$= 0.93) and between individuals and groups of similar subjects (mean $\underline{r}$= 0.93), while the scales themselves tend to be differentially sensitive to analgesic agents as would be predicted. Studies of social modeling effects on self-reported pain would clearly benefit from these more advanced assessment devices.

Another important question is the extent to which noxious stimuli employed in the laboratory induce pain comparable to that experienced by people in the natural environment and patients in the clinic. Of course, ethical practice and restrictions prevent laboratory researchers from inflicting persisting pain of clinical severity. But noxious stimuli may differ from one another along other quantitative and qualitative dimensions, and there is a great deal of evidence to suggest that different forms of tissue insult evoke qualitatively different pain experiences (e.g. Agnew & Merskey, 1976; Crockett, Prkachin, & Craig, 1977; Melzack, 1975; Leavitt, Garron, Whisler, & Sheinkop, 1978). With few exceptions (e.g. Neufeld & Davidson, 1971; Chaves & Barber, 1974), studies of modeling and pain have employed brief exposure to electric shocks as the noxious stimulus (cf. Craig, Note 1). Although electrical stimulation is advantageous from a measurement standpoint, it does not closely resemble the types of pain for which patients might seek clinical treatment (e.g. headache, backache, and postsurgical pain). Clinical pain typically involves more prolonged discomfiture, during which a wider variety of cognitive, affective, and behavioral events may influence one's reactions than may occur with electric shock (Turk, Meichenbaum, & Genest, 1983).

One laboratory technique that produces pain more closely resembling chronic clinical pain is the cold pressor test (Kunckle, 1949). The noxious stimulus in this case is exposure of some part of the body (usually the hand and part of the arm) to ice water maintained at a relatively constant temperature (e.g. $0^{o}C$). The cold pressor test first appeared as a method of elevating blood pressure in studies of hypertension (Hines & Brown, 1932), and has since been used as a pain-induction procedure in numerous investigations of hypnotic analgesia and other approaches to pain management (e.g. Anderson, Jamieson, & Man, 1974; Girodo & Wood, 1979; Hilgard et al., 1967, 1974; Johnson, 1974). The pain sensations are largely a function of local vascular responses to the cold water (cf. Lovallo, 1975). During long periods of exposure, there is alternating constriction and dilation of capillaries near the skin surface (Lewis, 1929) which are experienced by the subject as cyclic pain: Vasoconstriction is associated with sensations of aching, crushing pain while vasodilation is associated with numbness, local warming, and relief from the pain. The cyclic phenomenon of vasodilation accompanied by amelioration of cold-induced pain has has been dubbed the "Lewis effect". Since most subjects who experience the Lewis effect (some, in fact, do not) do so within 400 seconds

(Teichner, 1965), laboratory studies of pain using the cold pressor test have typically limited exposure time to between four and six minutes.

It would seem that the cold pressor test, unlike electric shock, delivers a noxious stimulus of prolonged duration which produces an aching pain more analogous to that experienced by chronic, clinical pain sufferers. Turk, Meichenbaum, and Genest (1983) have argued that the pain induced by the cold pressor test "seems closer to the quality, duration, and urgency of clinical pain" than does that induced by other laboratory techniques, including electric shock. It is not clear whether social modeling effects on pain tolerance would be as salient for the cold pressor stimulus as they appear to be for electric shock; if this were the case, though, one would feel more comfortable about generalizing these findings to pain of a clinical nature.

A third major research issue is whether social modeling merely influences what subjects report about their pain experience, or whether it actually affects pain perception. Because self-reports are multidetermined, they may not necessarily provide an accurate reflection of underlying experience: Unintentional or purposeful dissimulation may contaminate such reports (Craig, Note 1). Thus, it is not clear whether exposure to a tolerant or intolerant model simply affects subjects' willingness to report pain, or whether it alters fundamental affective and sensory characteristics of the pain experience.

Various studies have attempted to clarify this issue by examining behavioral indices of pain that are either relatively unamenable to voluntary control or normally not monitored by the individual. One approach has been to study subtle experiential phenomena associated with pain using psychophysical scaling procedures. For example, magnitude estimation (Stevens, 1957) provides a method whereby the rate of growth in perceived discomfort may be expressed as a function of physical characteristics of a noxious stimulus. Various investigators (e.g. Adair, Stevens, & Marks, 1968; Ekman et al., 1964, 1966; Hilgard, 1967; Stevens, Carton, & Shickman, 1958) have reported that the perceived magnitude of experimentally induced pain increases as a function of the physical value of the stimulus raised to a power. The magnitude of the exponent of the power function is believed to be related to cognitive moderating factors as well as operating characteristics of sensory transducers (Baird, 1970). Craig, Best, & Ward (1975) found that the magnitude of the power exponent for electric shock was altered when subjects were paired with a tolerant model: The size of the exponent was reduced, indicating a slower rate of increase in perceived discomfort. Craig and his colleagues interpreted these results as evidence that social modeling affects fundamental sensory properties of the pain experience.

Craig and Coren (1975) employed sensory decision theory (SDT; Price, 1966) methodology to determine whether altered pain reports due to social modeling reflected criterion shifts (i.e. response biases) or pain discriminability changes (i.e. changes in sensory sensitivity). Subjects received two ascending series of shocks in the presence of a pain-tolerant or pain-intolerant model or no model, and then were asked to rate 60 additional shocks (comprising five different intensity levels) according to painfulness. The intolerant-model groups showed a significantly larger discriminability index for adjacent shock intensities (indicating increased sensitivity) while the tolerant group's data suggested they had adopted a higher criterion for reporting pain. Craig and Coren concluded that sensory qualities of the pain experience can be altered by social modeling.

One problem with these psychophysical studies has been that the measures are ultimately derived from self-report data. Thus, it is conceivable that modeling-induced changes in the magnitude-estimated power function for electric shock (cf. Craig, Best, & Ward, 1975) may be due to factors other than changes in sensory qualities of the pain experience. A magnitude-estimated power function is simply a mathematical expression of the rate at which reported pain mounts over time in response to a noxious stimulus; there are no unambiguous explanations for modeling-induced changes in the power function that point exclusively to changes in sensory qualities of the experience. As such, modeling effects on the magnitude of power exponents represent empirical findings requiring further explanation. Moreover, regarding SDT, there has been considerable disagreement among researchers as to whether it is even applicable to the study of pain. According to Rollman (1977), "difficulty arises because the (SDT) studies do not determine a true estimate of the painfulness of a stimulus or allow an unbiased assessment of whether such painfulness has been reduced ... There is no certain way of knowing whether the experienced pain, in any given experiment, has been modified or not" (p. 208-209).

A solution to these problems would be to monitor indices of the pain experience which are independent of subjective self-report. Craig and Prkachin (1978) examined changes in psychophysiological indices of pain (non-palmar skin potential, palmar skin conductance, and heart rate) as a function of the social modeling manipulation. They found evidence of decreased sympathetic nervous system arousal to electrical stimulation as a result of exposure to a tolerant model, further supporting the claim that social factors can alter fundamental qualities of the pain experience. These results must be interpreted with caution, however: The relationship between pain experience and indices of autonomic arousal is highly inferential. Although psychophysiological measures have been used frequently to assess emotional arousal and distress, often with specific referents (e.g. guilt, fear, anger), such measures are also responsive to non-affective stimuli (cf. Craig & Wood, 1971; Lacey, 1967; Lang, 1971).

There is another source of objective information about pain states that has received little attention to date: nonverbal expression. This includes categories of behavior such as para-linguistic vocalizations (e.g. moaning, screaming, crying, quality and tone of voice) and various types of nonverbal, motoric expression - facial grimaces, withdrawal reflexes, protective posturing, medication use, etc. (Craig & Prkachin, in press). There is a good deal of evidence to suggest that such overt behaviors may convey valuable information about the experience of pain. Johnson (1977) interviewed nurses regarding the types of cues they used to assess patient pain and found that physiological signs and nonverbal expressions (e.g. body movement, facial expressions) were considered more useful than self-report. There is also evidence that verbal behavior is more likely to be discounted than nonverbal behavior when the two are inconsistent(Harper, Wiens, & Matarazzo, 1978). This is perhaps because people are less able to convey a false impression through what they do as opposed to what they say. The results of studies by Ekman and Friesen (1969, 1974) support this supposition: They found that nonverbal expressions of emotion were less amenable to conscious distortion than self-reports of subjective states. It seems that people do not monitor their nonverbal expressions to as great an extent as they do their verbal behavior. This suggests that in some cases unobtrusive measurement of the former might provide more accurate information about subjective states, including pain.

Despite the potential importance of nonverbal behavior as an index of the pain experience, "systematic study of these phenomena has been sparse, occasionally erroneous, and without substantial impact on the knowledge base in the field of pain" (Craig & Prkachin, in press). Nonverbal expression does not lend itself as readily to quantification as does verbal behavior, and comprehensive measurement strategies for the former have only recently begun to appear. One area that has enjoyed rapid progress over the last few years is the study of facial expressions as indicators of emotional experience. Although this field has a lengthy history, systematic attempts to measure facial expressive activity are a more recent development.

As early as 1872, Darwin wrote about the role of the facial musculature in the expression of emotion and proposed that universal facial expressions of emotion are inherited. The first laboratory studies in this area (e.g. Landis, 1929; Langfeld, 1918; Sherman, 1927) showed that untrained observers can discriminate different expressions of emotion on the basis of impressionistic judgments of facial features. Ekman, Friesen, and Ellsworth (1972), summarizing this early research, concluded that a minimum of seven categories of emotion can be distinguished by untrained observers on the basis of facial cues: happiness, surprise, anger, interest, fear, sadness, and disgust.

Later research efforts were aimed at specifying particular components of facial expression associated with different subjective experiences. Leventhal and Sharp (1965) found that intense distress (i.e. labour pain) elicited specifiable changes in the forehead, brow, and eyelid regions of the face. Ekman , Friesen, and Tomkins (1971) developed a system for measuring facial behavior called the Facial Affect Scoring Technique (FAST). This method involved scoring observable movements in each of three areas of the face: a) brows/forehead area; b) eyes/lids; and c) lower face, including cheeks, nose, mouth, and chin. Photographic examples were provided as prototypes of specific movements within each area of the face which theoretically distinguished among six emotions. Ekman, Friesen, and Malmstrom (Note 2), using an early version of this technique, demonstrated that subjects displayed more facial behavior characteristic of surprise, sadness, disgust, and anger during a stress-inducing film and more facial activity characteristic of happiness during a neutral film. A facial components study by Boucher and Ekman (1975) supported their hypothesis that the facial area which provides the most information about the presence of a particular emotion varies from emotion to emotion. They found, for example, that the cheeks and mouth were the most salient cues for recognizing disgust, while the brows/forehead and eyes/eyelids were most prominent in the expression of sadness.

Perhaps the most sophisticated development to date in the measurement of facial expressive behavior is the Facial Action Coding System (FACS; Ekman & Friesen, 1976, 1978a, 1978b). This system was designed to measure all visible facial behavior, not just that presumably involved in emotional expression. It is based on the analysis of the anatomical basis of facial movement - the examination of how each muscle of the face acts to create a visible appearance change. FACS distinguishes 44 separate facial Action Units (discrete movements in the forehead, eye, cheek, nose, mouth, chin, and neck regions) along with 20 additional Action Descriptors (e.g. changes in the orientation of the head and eyes). Any facial expression can be described in terms of the action unit (AU) or combination of AU's that produced it. FACS can also be used to code the duration and intensity of facial movements. The system is extremely comprehensive and complex, and requires considerable time and practice to master. Due to this complexity, and various ambiguities in the system, interscorer reliability tends to be some what less than perfect - for example, Ekman and Friesen (1978a) reported an interscorer reliability figure of .76 for the coding of AU occurrences.

The main advantage of FACS is that it permits the investigator to exhaustively specify the components of facial expression in an objective fashion. Although the authors have offered predictions about what AU's are likely to be associated with particular emotions (Ekman & Friesen, 1978a), the coding system itself was developed without reference to affiliated emotions. The intention was to develop an objective scoring system for facial activity which could serve as the basis for subsequent validational studies (i.e. to identify relationships between inferred subjective states and overt AU's or combinations of AU's). Such studies have recently begun to appear.

Using FACS, Ekman, Friesen, and Ancoli (1980) found that variation in particular facial actions was related to the degree of self-reported happiness or unhappiness evoked by a pleasant or stress-inducing film. For example, they found that AU 12 ("lip corner puller"), which is due to action of the zygomatic major muscle, produces the type of smile most frequently associated with happiness. They also found evidence to suggest that facial actions may be specific to each negative emotion. A FACS study by Ekman, Hager, and Friesen (1981) indicated that asymmetrical facial expressions (i.e. with movements more predominant on one side of the face) occur more frequently in posed as opposed to spontaneous emotional expressions. One problem with these studies was that they tended to adhere to a univariate model: Data analyses in the Ekman, Friesen, and Ancoli (1980) study, for example, used as dependent variables either a single AU or an aggregate of AU's (e.g. the sum of all AU's believed to be associated with negative affect; facial actions hypothesized as signs of disgust). A multivariate approach, using several AU's as separate dependent variables, would provide more information about specific facial units involved in different types of emotional expression. The validity of the emotional experiences examined by these authors is also open to question. It is unclear whether subjective experiences induced by watching films are representative of emotions evoked by real events.

Although the FACS technique has not yet been applied to the study of pain expression, there is reason to believe that specific facial movements may be associated with the experience of pain. Boucher (1969) provided evidence that there are separate and distinguishable facial expressions for fear, sadness, and pain, although he did not specify the unique features of the pain expression. Leventhal and Sharp (1965) used their own coding system to examine the facial expressions of women experiencing labour pain. They concluded that some signs of "distress" (e.g. heavy knitting and furrowing of the brow) do not appear unless a certain minimum level or threshold of pain is exceeded; others (e.g. "forehead discomfort", minor brow movements) vary more continuously with increases in noxious stimulation. Unfortunately, it was not clear to what extent facial movements here were a function of pain per se or other stressful features of the situation.

Hjortsjo (1969) offered more specific descriptions of facial regions involved in the expression of pain. Two skeletal muscles - the obicularis oculi, which surrounds and narrows the eye, and the masseter, which clenches the jaw - were thought to be particularly salient. A third location - the medial frontalis, which raises the eyebrows - was assumed not to participate in the pain expression. On the basis of Hjortsjo's descriptions, one would expect the following AU's to participate in the facial expression of pain: AU 4 (brow lower), AU 6 (cheek raise), AU 7 (lids tight), AU 9 (nose wrinkle), AU 11 (nasolabial deepen), AU 14 (dimpler), AU 15 (lip corner depress), AU 17 (chin raise), AU 20 (lip stretch), AU 23 (lip tight), AU 31 (jaw clench), and AU 44 (squint). Also consistent with Hjortsjo's descriptions are AU's 10 (upper lip raise), 21 (neck tighten), 24 (lip press), 25 (lips part), 43 (eyes closed), and 45 (blink). Although Hjortsjo's descriptions of the components of the pain expression are the most detailed available, one must be cautious about assuming that they reflect the true state of affairs. His account was based on observations of actors mimicking expressions of severe pain, as opposed to actual pain sufferers. As such, his descriptions should be regarded as hypotheses requiring empirical validation.

The data discussed to this point suggest that measurement of facial expressive behavior may provide useful information about the subjective experience of pain. Evidence that social modeling influences on self-report and other pain indices are accompanied by changes in nonverbal behavior (e.g. facial expression) would further support the assertion that social factors effect fundamental changes in the experience of pain (Craig, Note 1). Prkachin and Craig (Note 3) exposed subjects to electric shocks in the presence of a tolerant, intolerant, or inactive model and subsequently videotaped their reactions to a random series of low, medium, and high intensity shocks. Later, naive observers examined the videotapes, using nonverbal cues to rate the current intensities delivered. As predicted, observers were relatively accurate in their judgments, suggesting that pain experiences were encoded in nonverbal expression. Also, judges experienced the greatest difficulty discriminating current intensities for subjects who had been paired with a tolerant model, the implication being that the tolerant-modeling influence strategy reduced overt pain behavior. Prkachin, Currie, & Craig (in press) replicated these findings, and also reported data on the types of nonverbal cues utilized by observers in making judgments: Observers identified facial activity as particularly important.

Statement of the Problem

In the present study, an attempt was made to more precisely identify and quantify facial expressive behaviors that serve as cues for observers' judgments of pain. As well, the study addressed the question of whether social modeling influences on self-report indices of pain are accompanied by measurable changes in nonverbal (i.e. facial expressive) behavior.

An effort was made to improve upon the methodology of earlier studies of social modeling and pain. In response to suggestions that cold-induced pain more closely resembles clinical pain (e.g. Turk, Meichenbaum, & Genest, 1983), the cold pressor test replaced electric shock as the noxious stimulus in the present study. Subjects underwent the cold pressor test conjointly with a confederate, the latter assuming either a tolerant, intolerant, or inactive role. During noxious stimulation, subjects provided periodic ratings of discomfort on an ascending scale of affective descriptive adjectives (Gracely, McGrath, & Dubner, 1979). Gracely et al. (1978a, 1978b, 1979) have quantified scales of this type through cross-modality matching procedures, and provided evidence for their reliability and validity. As such, the self-report measure used in the present study represented a considerable improvement over the unstandardized measures used in previous studies of this type.

In addition to the self-report measure, subjects were videotaped during cold pressor exposure to provide a record of their facial expressive behavior during the period of noxious stimulation. Although the subjects were informed in advance of the videotaping procedure, the camera was positioned behind a one-way mirror to minimize subject awareness of our interest in facial behavior. While there is evidence that facial expressions are less likely to reflect subjective experience when the subject is aware that his/her behavior is being monitored (Kleck et al., 1976), it was hoped that minimizing the obtrusiveness of observation would lessen this effect.

FACS scoring was subsequently used, first, to identify AU's associated with pain in the sample as a whole, and second, to determine whether the modeling manipulation produced changes in the occurrence of these facial indices. It was hypothesized that relative to controls, subjects exposed to a tolerant model would tolerate the cold pressor for a longer period of time, report less distress, and show fewer facial signs of discomfort during noxious stimulation; intolerant-group subjects, on the other hand, were expected to exceed controls on both self-report and facial indices of pain.

It was also hypothesized that social modeling influences on facial indices of pain would be more salient if subjects were given the opportunity to see their partner, with the model maintaining a facial expression consistent with her modeling role (i.e. a "stoical" expression in the tolerant condition; a "pained" expression in the intolerant condition). Without exception, previous studies of modeling and pain (e.g. Craig, 1978a; Craig, Best, & Best, 1975; Craig, Best, & Ward,

1975) had separated the subject and model by a screen, preventing them from seeing one another; modeling took place because the subject and model were able to see or hear each other's ratings of discomfort. Additional cues regarding tolerance or intolerance were expected to accentuate the modeling effect. Vaughan and Lanzetta (1980) elicited both facial expressive and autonomic responses from subjects in a vicarious conditioning paradigm where the subjects did not experience pain directly, but merely witnessed an expressive model receiving electric shocks. A similar modeling condition, with the subject receiving noxious stimulation concurrently, was expected to magnify this effect. On the other hand, co-participation with a visibly stoical model was expected to lessen facial expressive behavior. To test this hypothesis in the present study, half of the subjects in each of the three modeling conditions (tolerant, intolerant, control) were screened from the confederate, while the other half were not.

Method

Subjects

Subjects were 72 female introductory psychology students drawn from the departmental subject pool at U.B.C. Their ages ranged from 17 to 25 years with a mean of 18.65 years (SD=1.58). Female subjects were used because they tend to be more overtly expressive (cf. Buck, Miller, & Caul, 1974; Schwartz, Brown, & Ahern, 1980). Twelve subjects were assigned randomly to each of the six experimental groups.

Due to equipment failure or procedural irregularities, nine subjects had to be replaced. Two subjects were dropped because the videorecorder malfunctioned during the testing session; another four were eliminated because their faces were out of camera range during either the baseline or cold pressor phase of the session. Two more subjects had to be dropped because of confederate errors in the modeling routine. One final subject was replaced because she withdrew before the session was completed. The mean age of those replaced was 17.77 years (SD=0.92), with a range of 17 to 19 years. These subjects were not predominantly from any one experimental group: Three subjects were replaced in each of the tolerant, intolerant, and control groups; of these, five were in the "visual" condition, four in the "nonvisual" condition.

Subjects were paid $5.00 for their participation in the study. The offer of remuneration was not made until after they had agreed to participate.

Models

The models were two female undergraduates (ages 21 and 24) and one female graduate student (age 31) paid to assume roles of tolerance or intolerance to pain, or in the case of the control groups, non-participatory presence. They were assigned randomly to subjects, with the constraint that they appear equally in all experimental conditions. The models were treated as naive subjects, but were not subjected to the pain stimulus.

Apparatus

Cold pressor test.

The cold pressor apparatus consisted of a commercial styrofoam cooler fitted into a box-like wooden frame, painted black to provide a more impressive appearance. The container was separated into two compartments by a Plexiglas barrier. One compartment contained crushed ice, the other water. Holes were drilled through the Plexiglas barrier and covered over with wire mesh to permit the water to enter and cool without the ice escaping. The ice compartment contained a circulating pump (Rule, 400 gal. per hr.) with a plastic hose feeding into the water compartment. The pump served a dual purpose. First, it allowed the water to continuously circulate through the ice compartment, thereby maintaining it at a low temperature. Second, it prevented localized warming near the skin surface of the immersed hand.

The lid of the styrofoam cooler was painted black and used as a cover for the cold pressor apparatus. A small hole was cut through the cover to admit the subject's hand into the cold water compartment. To ensure that only the hand and wrist entered the cold water, a metal flange was attached to the subject's arm at a point just below the elbow joint. The flange consisted of two L-shaped pieces of metal secured to a velcro strip which encircled the subject's arm. Upon insertion, the two projecting edges of the flange made contact with a metal strip surrounding the opening in the cover of the cold water bath. This completed a circuit activating a battery-operated relay device. The device produced a click upon insertion of the subject's hand, and then again upon withdrawal from the cold pressor apparatus. A microphone attached to the relay recorded this sound on the audio channel of the videotape recorder. The time interval between clicks provided a precise measure of the duration of exposure to the cold water bath.

The metal flange attached to the subject's arm extended 9 cm down from the joint of the elbow. The distance between the top of the cold pressor tank and the surface of the circulating ice water was approximately 7 cm. Thus, for each subject, the part of the arm from the fingertips to a point 16 cm below the elbow joint entered the cold water.

The cold pressor apparatus rested on the front half of a wooden platform, with the opening to the cold water compartment nearest the subject. A similar container, filled with room temperature water (approx. 20°C), occupied the rear half of the platform. The platform itself was mounted on legs to raise the containers to a height easily accessible to a seated person. The legs had wheels so the subject could gain access to either container by adjusting the position of the platform.

The model's apparatus was identical to that described for the subject except that her cold pressor tank contained no ice. The Plexiglas barrier enclosing the ice compartment was painted black so this difference would not be visible through the opening in the lid of the tank.

Prior to each session, the ice compartment of the subject's cold pressor tank was filled. Crushed ice was also added to the water compartment to bring the temperature down quickly to 0°C, but this was removed before the subject was brought in. The water temperature was checked again after each session, and in no case had it risen by more than 1°C.

Self-report measure.

Subjects rated their discomfort at ten second intervals by depressing buttons on a panel. The panel consisted of an oblong metal box with 12 equally spaced push buttons on its face. A small jewel light was positioned above each button, and this lit up when the button was pushed. The 12 panel buttons were labelled with affective descriptive adjectives arranged in an ascending order from left to right ("slightly unpleasant" to "very intolerable"). Gracely, McGrath, & Dubner (1979) quantified these affective descriptors in the form of a ratio scale (each adjective having an assigned, numerical weight) and provided evidence for its reliability and validity (Gracely, McGrath, & Dubner, 1978a, 1978b). The 12 affective descriptors and their respective numerical weights are presented in Appendix A.

The subject and the model alternated ratings, with a five-second lapse between their responses and the subject reporting first. The self-report panel was suspended on a wooden stand resting on a small table in front of and between the two participants. It was positioned near eye level so that the subjects would keep their heads up while rating, making it easier to capture their facial expressions on videotape.

The panel was clearly visible to both subject and model, permitting them to observe each other's responses. This enabled the model to monitor the subject's responses, and adjust hers accordingly (the model's reports reflected either more or less discomfort than the subject's, depending on whether she was assuming an intolerant or a tolerant role). At the same time, the subject had the opportunity to compare her responses with those of the model.

A tape recorded voice cued the participants to make ratings on the panel. Responses were relayed to a similar panel in the adjoining room and recorded by the experimenter. The model's responses were recorded in addition to the subject's, so that her adherence to a predetermined rating scheme could be evaluated.

Videotape equipment.

Subject facial expressions were recorded through a one-way mirror onto Scotch T-120 video cassettes, using an RCA TC 2011/N high sensitivity black and white TV camera and an RCA model VET 650 video cassette recorder. An RCA video date/time generator, model TC 1440-B, was connected to the video cassette recorder. It provided the videotapes with a digital time display (minutes, seconds, 60ths of a second) so they could subsequently be divided into segments for FACS coding.

An RCA model JD-975VW 19-inch television screen displayed the camera input during filming. The same monitor was used to play back the videotapes for FACS coding purposes. It was equipped with a remote control unit offering "pause", "slow motion", and "single frame advance" capabilities to facilitate scoring.

For the purpose of reliability checks, the model's facial expressions were also recorded during visual modeling sessions (i.e. where the subject and model were not separated by a screen). The models were filmed with an RCA Color Video camera, model 0516V M 039. The camera was equipped with a miniature TV monitor to facilitate adjustment. It was positioned behind the one-way mirror alongside the camera used to record subject facial expressions. Recordings were made on Sony V-30H reel-to-reel videotapes via a Sony-Matic Portable Videorecorder, model AV-3400. A Sony CVM-110VA Transistor Video Monitor was used to play back the model tapes for reliability checks.

Procedure

Upon her arrival outside the laboratory, the subject was taken to a separate room and asked to wait there until "another subject" arrived. The experimenter left and returned a few minutes later with the model, who had been waiting inside the laboratory. The subject and model were introduced, and the latter was asked to take a seat at a table facing the subject. The model was treated at all times as a naive subject.[1]

The experimenter then proceeded to explain the nature of the experiment. It was described as a study of "people's physiological reactions to cold water and how they perceive the discomfort it

1 Henceforth, the term "subject" will be used in the text to refer to both participants in a session (ie. subject and model) unless otherwise specified.

produces". The subject was told that she would be asked to place her hand into a cold water bath. She was assured that this would not result in physical harm, and that she would be free to withdraw her hand from the bath at any time. The experimenter then said:

> Your task will be to keep your hand in the cold water bath for as long as possible and to periodically rate your experience while doing so. In addition to collecting your ratings, we will be monitoring your heart rate through electrodes attached to your neck and shoulder.[2] We will also be videotaping the session for our records.

Following this explanation, the subject was assured that participation in the study was completely voluntary and that she was "free to withdraw now or at any time" during the experiment. The subject was also queried as to possible medical conditions which might make participation inadvisable. Barring refusal or medical complications, the subject was asked to read and sign a consent form (see Appendix B). One subject was excluded for medical reasons; none refused to participate.

2 Although portrayed as measuring heart rate, the real purpose of the electrodes was to keep the subject fairly still during the session so she could be videotaped without interruption.

The experimenter then led the participants to the laboratory and into the testing chamber. This room, approximately 3 m by 3 m, housed the room temperature and cold water tanks, the table on which the self-report panel was mounted, and two wooden chairs. The room was lighted by two bare, overhead light bulbs and two standup lamps positioned to provide optimum illumination for videotaping.

The subject and model were seated behind the table facing the one-way screen through which videotaping took place. For half the subjects, the model sat on the left and the subject on the right. For the other half, the opposite seating arrangement was used. The water tanks were situated on the outside of each participant, hence half the subjects received right hand exposure, the other half left hand exposure. Each of the experimental conditions was evenly balanced for this variable. Due to the logistical difficulties involved in changing subject position from left to right (e.g. switching cold pressor tanks, altering camera angles, etc.) all subjects receiving left hand exposure were run first, followed by those receiving right hand exposure.

Once the subject was seated, the experimenter explained the procedure in more detail. The subject was told that she would be asked to place her hand into the room temperature water to begin with, and then into the cold water bath. Initial exposure to the room temperature bath was provided to ensure comparable experience and exposure for all subjects prior to the cold pressor.

The subject was asked to remove any jewelry she was wearing on the hand to be immersed. The experimenter then attached the flange to her arm, explaining its function as a stopper. The subject was told that contact between the metal flange and the metal strip on the lid of the cold water tank would activate a timer to measure exposure time. The subject was asked to maintain contact between these surfaces during the experiment so as not to disrupt the timing.

The experimenter then told the subject that in addition to keeping her hand in the cold water bath for as long as possible, she would be asked to rate her feelings of discomfort every 10 seconds. The ascending nature of the scale was explained, and the subject was told to report her discomfort by pressing the button on the panel best describing her sensations at the moment a rating was requested.

The experimenter then said:

> I will be in the other room during the session. Before I leave I will ask you to place your hand into the room temperature bath and I will also turn on this tape recorder to provide further instructions. After about two minutes the taped instructions will say "Hand Out" - take your hand out of the room temperature bath and position it over the opening of the cold water bath. Do not put your hand into the cold water bath until the taped instructions say "Hand In".

At this point, the experimenter positioned the water tanks so that the subject could comfortably reach the room temperature container. "When the taped instructions say 'Hand Out'", the subject was told, "you should move the dolly to a position where you can insert your hand into the cold water tank while maintaining a comfortable sitting position".

The experimenter explained that following the "Hand In" instruction the tape would begin requesting ratings from the two participants in turn. The experimenter assigned the letter "A" to the subject and the letter "B" to the model. When the tape said "A, rate" the subject was to provide a rating on the panel; when it said "B,rate" the model was to do likewise. Participants were instructed to rate quickly after each and every request, and not to rate out of turn.

The subject was then reminded that the study was concerned with how long she could tolerate the cold water bath. She was told that the intensity of her discomfort would increase over exposure time to a point at which she would no longer wish to continue. She was urged to keep her hand in the ice water beyond this point, until under no circumstances could she continue for even one second more (cf. Hilgard et al., 1974). At this time, she was to raise her hand out of the water and rest it on the lid of the cold pressor tank until the experimenter returned to the testing chamber. To avoid any risk of physical harm, maximum exposure time was limited to six minutes, the length of time between "Hand In" and "Hand Out" instructions.

Next the experimenter attached the polygraph electrodes, one to the back of the subject's neck, the other to the upper part of the arm that was to be immersed in the water. The procedure was the same for the model. The electrodes were not actually functional, but they ostensibly were connected to a Grass Model 7 polygraph (visible in the anteroom through which the participants passed to enter the testing chamber) to enhance credibility. After attaching the electrodes, the experimenter said: "Please try not to move around and talk during the experiment because you may disturb the readings I'm taking on the polygraph".

The experimenter then left for a brief period to "adjust the polygraph" in the anteroom. The participants were asked to refrain from talking or moving around in the interim. The experimenter took this opportunity to film the subject for approximately 30 seconds. This was done to obtain a "neutral" videotape segment prior to the subject's exposure to either of the two water baths. This segment served as a standard against which changes in facial expressions during testing could be compared in subsequent FACS analyses.

The experimenter then returned to the testing chamber and answered any questions the subject had (within the limits of the previous instructions). The participants were then asked to immerse their hands in the room temperature bath, keeping their fingers in a loosely curled position. The experimenter briefly reviewed the foregoing instructions, started the tape recorder, and then left the room, closing the door behind him.

In the anteroom, the experimenter extinguished the lights and switched on the subject camera (and the model camera if the condition was "visual"). The camera was focused to record a close-up of the subject's face and neck regions. The subject was recorded for at least 30 seconds during exposure to the room temperature bath to obtain a "baseline" segment. Filming continued throughout her exposure to the cold water bath. The experimenter also recorded the subject's self-reports during the cold pressor test. The model's ratings were recorded at the same time so they could be checked for adherence to the appropriate rating scheme (i.e. tolerant or intolerant).

After both participants had withdrawn their hands from the cold water baths, the experimenter returned to the testing chamber with towels and allowed them to dry their arms. The subject and the model were then led back to the room where they first met to complete a post-test questionnaire (see Appendix C). The questions were aimed at investigating the subject's perception of the experimental situation, and hence served mainly as a manipulation check. After the questionnaire was completed, the subject was informed of the true nature of the experiment: the model was identified as such, our interest in the videotapes of facial expressions revealed, and the reason for the deception involving "physiological recordings" was explained. After answering questions from the subject, the experimenter paid her and expressed appreciation for her participation in the study. The subject was asked to refrain from discussing the experiment with her fellow students in case some of them subsequently participated. The debriefing instructions are presented in full in Appendix D.

Experimental Design and Groups

There were six groups. Within each of two "Cue Conditions" (nonvisual, visual), subjects undertook the cold pressor test in the presence of either a "tolerant" model, an "intolerant" model, or in the case of the control group, an inactive companion. There were 36 subjects in each Cue Condition, equally divided among the three Modeling groups.

The design was thus a 3 x 2 Factorial: Type of Modeling (tolerant, intolerant, control) x Cue Condition (nonvisual, visual).

Nonvisual Cue Condition.

In this condition, a wooden screen separated the two chairs in which the subject and model were seated, blocking their view of each other. Thus, modeling was restricted to the subject's view of the ratings made by the model during the cold pressor test.

1. Tolerant Modeling.

The model consistently rated her discomfort at lower intensity levels than the subject, generally remaining one descriptor behind. She began with the lowest rating on the control panel ("slightly unpleasant") and continued at this level until the subject's rating was two or more descriptors above this point. At this time the model made one more rating of "slightly unpleasant" and then advanced to the next higher descriptor. On each subsequent occasion that the subject advanced one or more steps on the scale, the model remained at the same level for one more rating before advancing a single step. If the subject remained at any particular rating level for only one self-report or advanced by skipping one or several descriptors, the model advanced at a rate of one descriptor per self-report until she was again behind by one descriptor. One further contingency was established to facilitate the deception involved in the model's role. The model advanced to the subject's level if the model had made eight consecutive ratings at a level immediately below that chosen by the subject. Once the subject reached the top of the rating scale and terminated cold pressor exposure, the model proceeded at a rate of two descriptors per self-report toward the top of the scale (unless the model was already there). The model then selected the highest descriptor on the scale for two self-reports before removing her hand from the ice water bath.

This procedure is adapted from that used by Craig, Best, and Ward (1975).

2. <u>Intolerant modeling.</u>

The model consistently rated her discomfort at higher intensity levels than the subject. Whenever possible the model selected descriptors one level higher. The model's first rating matched that given by the subject, followed by a rating of one descriptor higher for the second self-report. When the subject advanced to match the rating of the model, the latter remained at that level when the next report was requested, and then proceeded to the next higher descriptor, provided that the subject remained at the prior level. If the subject remained at any rating level for only one rating period or skipped one or several descriptors, the model responded by advancing to the descriptor one greater than that chosen by the subject, providing the jump did not require the model to advance more than three descriptors higher than that chosen on her previous self-report. Once the model reached the top of the rating scale, she selected the highest descriptor for two self-reports and then withdrew her hand from the ice water bath.

Again, this follows the procedure employed by Craig, Best, and Ward (1975).

3. <u>Control.</u>

This condition was included to control for the simple presence of a peer in the experimental setting. Subjects were accompanied by a confederate, but the latter did not act as a model. After all instructions were completed, subjects in this group were told that they would be receiving the cold pressor test first, with their "partner" to undergo exposure after they finished. The inactive confederate sat on the other side of the wooden screen from the subject. A slightly different set of instructions was required for the control group, eliminating all reference to concurrent participation. Instructions for the rating procedure were altered. Instead of labeling the participants "A" and "B", and telling them that they would be asked to rate in alternation, the experimenter said:

> Shortly after the tape instructs you to drop your hand into the cold water tank, it will begin requesting ratings from you. When the taped instructions say "rate" you should rate the discomfort in your hand by pressing the button which best describes your sensations at that time.

The experimenter then informed the subject that she would be participating first, followed by the model. The rationale given was that the equipment was set up to handle only one subject at a time. The model was asked to remain silent so as not to disturb the subject during her exposure to the ice cold water. Before leaving the room to start the session, the experimenter asked the subject alone to immerse her hand in the room temperature bath, and provided her with an abbreviated version of his previous instructions. At the end of the cold pressor test, the subject was taken to the other room to fill out the post-test questionnaire alone, and was then debriefed. Aside from these changes, the instructions given the control subjects were identical to those for the experimental subjects.

Visual Cue Condition.

In this condition, there was no wooden screen separating the subject and model. During the cold pressor test, the model maintained a facial expression consistent with her modeling role. With the screen absent, the subject had the opportunity to witness the model's facial expression during the session as well as her discomfort ratings.

1. Tolerant Modeling.

In addition to reporting less discomfort than the subject, as in the nonvisual tolerant modeling condition, the model maintained a "neutral" facial expression during the cold pressor test. This consisted of a relaxed, nonexpressive facial posture (i.e. showing no scorable AU's by FACS standards). The model assumed a neutral expression upon immersing her hand in response to the "Hand In" instruction, and maintained this expression until she withdrew her hand from the water bath.

2. Intolerant Modeling.

The model made consistently higher reports of discomfort than the subject, as in the nonvisual intolerant modeling condition. In addition, she maintained a "pained" facial expression during the time her hand was in the simulated cold pressor apparatus. This expression consisted of Action Units 4 (brow lower), 10 (upper lip raise), and 25 (mouth open) in combination. These are some of the AU's that, on the basis of Hjortsjo's (1969) descriptions, one might hypothesize to be involved in the expression of pain. This specific combination of AU's was chosen because: a) it could be mastered, and reliably produced, without extensive practice, b) it could be held for up to 6 minutes without major difficulty, and c) it was clearly visible on the face when viewed from one side. This latter reason was important because the subject and model were seated side by side, and in this and other visual modeling conditions, the confederate was asked to face forward during the cold pressor test. Therefore, visual modeling cues were restricted primarily to the subject's side view of the model.

3. Control.

As in the nonvisual control condition, the confederate was inactive during the subject's exposure to the cold pressor. In addition, she maintained a "neutral" expression throughout this period.

For a more detailed description of the confederate training procedure, refer to Appendix E.

FACS Data Coding

Five 10-second segments from each subject's videotape were selected for scoring. The first of these was a "baseline" segment, taken while the subject had her hand immersed in the room temperature water. The 10-second "baseline" segment corresponded to the first 10 consecutive seconds of the 30-second baseline record that were scorable (i.e. where the subject's face was wholly visible for scoring). This segment was selected to provide a record of spontaneous facial expression which could be compared with facial behavior during exposure to the noxious cold pressor test.

Segment 2 corresponded to the first 10 seconds of cold pressor exposure for each subject, that is, facial expressive behavior occurring in the 10-second period immediately following immersion of the hand in the ice cold water bath. This segment was chosen so that subjects' initial reactions to the noxious stimulus could be compared with their behavior at later points.

Segment 3 provided a record of the subject's facial behavior during the 40 to 50 second mark of cold pressor exposure. Since all subjects retained for analysis withstood the cold pressor test for at least 60 seconds, Segment 3 was available for the entire sample. Thus, it was possible to compare the facial behavior of subjects in the different experimental conditions after a comparable period of reasonably substantial exposure to the cold pressor test, during which modeling influences presumably would have been operating.

Segment 4 was selected so that the expressive behavior of subjects in the different groups could be compared at ostensibly the same level of self-reported discomfort. It corresponded to the 10-second period immediately preceding the first rating higher than 6 ("very unpleasant") on the 12-point rating scale. This rating level was chosen because it is beyond rating 6 that the self-report descriptors appear to be denoting "pain" as opposed to slight discomfort or unpleasantness. For most subjects (i.e. 45 of 72), Segment 4 thus consisted of the 10 seconds preceding a rating of 7 ("distressing") on the scale. For subjects who skipped this particular rating, self-reports corresponding to Segment 4 were slightly higher on the scale: rating 8 ("very annoying") - 12 subjects; rating 9 ("slightly intolerable") - nine subjects; rating 10 ("very distressing") - one subject (segment 4 was not available for five subjects - i.e. those who did not advance past rating 6 during the cold pressor test). In short, Segment 4 was chosen to provide a sample of subject facial behavior during early reports of experiences akin to "pain".

Segment 5 corresponded to the last 10 seconds of cold pressor exposure for each subject; that is, facial expressive behavior occurring in the 10-second period immediately preceding withdrawal of the hand from the ice cold water bath. This segment was selected to permit group comparisons of facial expressiveness at the point where subjects reported maximum discomfort.

These five segments of each subject's videotape were located by the experimenter, and their positions specified via the time display provided by the time-date generator. This was the only information given to the FACS data coders, rendering them "blind" to the group membership of the subjects.

The data coders were a full-time research technician and a graduate student research assistant thoroughly trained in the use of FACS. Both had successfully met the reliability criteria for scoring required by the authors (Ekman & Friesen, 1978a) for certification as proficient FACS coders.

Each segment of videotape was scored for all 64 facial action units (AU's) and action descriptors (AD's) specified by the FACS system. For each AU or AD scored in a particular segment, three types of information were derived. First, the frequency or number of appearances of each AU/AD in a segment was recorded. Second, the onset and offset of each AU/AD appearance was scored so that the duration of a particular facial action in a segment could be calculated. In this case, a procedure known as apex scoring was used. According to Ekman & Friesen (1978a), the apex of an AU/AD refers to "the period during which the movement was held at the highest intensity that it reached" (p. 145). Scoring the apex onset and offset of an action is preferable to scoring first evidence of appearance/complete decay for two reasons. First, reliability is likely to be better with the former. Second, Ekman & Friesen suggest that apices may be more critical for defining emotional expression than absolute onset/offset. For example, they suggest that two or more AU's may be regarded as elements of a unitary expression when their apices are observed to overlap in time.

Finally, for AU's and AD's which could be scored for intensity (AU's 5, 10, 12, 15, and 20, and certain head and eye position AD's), the apex intensity was recorded for each appearance in a segment. Ekman and Friesen (1978b) specify three levels of action intensity (low, moderate, high) and provide scoring criteria for each level.

A complete list of the facial action units and descriptors specified by the FACS system may be found in Appendix F.

Results

The results of this study are presented in four separate sections. First, reliability figures are given for confederate modeling roles (ratings and posed facial expressions) and FACS scoring of subject facial expressions. Next, the results of various manipulation checks are presented. Checks were made on initial group comparability and subject perceptions of various aspects of the experiment. The third section outlines an analysis of the effects of the independent variables (Modeling, Cue) on various self-report indices of pain sensitivity. The principle purpose of this analysis was to determine whether findings from previous studies of modeling and pain (e.g. Craig, Best, & Best, 1975; Craig & Coren, 1975; Craig & Weiss, 1971) were replicated in the present study. The final section presents the results of analyses of the FACS data. One set of FACS analyses was performed to identify AU's which were more prominent during noxious stimulation than during baseline, that is, to determine which facial expressive components were associated with the experience of pain. A second set of FACS analyses examined the effects of the Modeling and Cue manipulations on the occurrence of these "pain AU's" during the period of noxious stimulation. The issue here was whether modeling effects on self-report indices of pain would be accompanied by changes in facial expressive indices of pain, and whether access to visual modeling cues would accentuate any such effects. A final set of analyses examined more directly the relationship between self-report and facial expression as indices of the pain experience; correlations among AU's associated with pain were also examined.

Reliabilities

Confederate ratings.

A reliability check was performed to determine how well the models adhered to the predetermined rating schemes in the experimental conditions. A correct decision was defined as a rating by the model which followed the rules of the rating scheme for a particular condition. The maximum number of decisions made by the model per subject was 36 - i.e. the number of ratings the confederate would make if the subject tolerated the cold pressor test for a full six minutes.

The reliability index was the ratio of the number of correct decisions to the total number of decisions made by the models in the experiment. The magnitude of this ratio was calculated to be .98, attesting to the ability of the models to conform to the prescribed role.

Confederate facial expressions.

A second reliability check examined the models' consistency in maintaining facial expressions required in the visual condition. In this condition, models were instructed to maintain a neutral expression during "tolerant" and "control" sessions, and a "pained" expression (consisting of AU's 4, 10, and 25) during "intolerant" sessions.

A random sample of 25% of the model videotapes, divided into 5-second segments, was scored using FACS. The scorer was "blind" to experimental condition (i.e. tolerant/intolerant/control). This check revealed that models maintained a completely neutral face throughout 95% of the segments obtained from the tolerant and control conditions. The models also managed to maintain the required "pain" face (AU's 4, 10, and 25) throughout 98% of the segments taken from the intolerant condition. However, 48% of these segments contained one or more additional AU's. Fortunately, over 80% of these "other AU's" were either AU 6 or AU 7, minute eye narrowing movements consistent with Hjortsjo's (1969) description of the pain expression. In other words, fully 92% of videotape segments obtained from models in the intolerant condition contained only AU's hypothesized to participate in the expression of pain.

A second "blind" coder performed a reliability check on the first coder's scoring. This involved coding 25% of the above data. Reliability was calculated according to the formula recommended by Ekman and Friesen (1978a):

$$\text{Reliability} = \frac{\text{No. of agreements} \times 2}{\text{Total no. of AU's scored}}$$

The resultant interscorer reliability figure was .91.

FACS scoring of subject facial expressions.

Reliability scoring was performed on a random sample of 20% of the data coded by the primary coder, subject to the constraint that all subjects were represented in the reliability check. To meet this criterion, an independent "blind" coder scored one segment chosen at random from the five videotape segments obtained from each of the 72 subjects.

Separate reliability figures were calculated for AU/AD frequency, apex onset/offset, and intensity information. Of course, onset/offset and intensity agreement could be calculated only for AU/AD occurrences that both coders agreed upon (i.e. "frequency" agreements).

Reliability for frequency scoring was calculated as:

$$\frac{\text{No. of agreements about the occurrence of an AU or AD} \times 2}{\text{total no. of AU's and AD's scored}}$$

An agreement was scored only if the two coders reported an AU/AD as occurring at approximately the same point in a segment. For all the AD's, and the majority of AU's, an agreement was scored if the time during which an AU/AD was said to have occurred by one scorer overlapped with that reported by the other scorer. For AU 45 (blink), which is, by definition, brief in duration, the two scorers had to concur within .2 seconds on the time of occurrence for an agreement to be scored. Under this requirement, the overall frequency reliability was .71. This is slightly lower than figures reported in other FACS papers. Ekman and Friesen (1978a) reported a mean reliability figure of .76; the reliability level achieved by Ekman, Friesen, and Ancoli (1980) was also .76. The figure reported by Ekman, Hager, and Friesen (1981) was substantially higher (.87), but this score was based on scoring of deliberately performed actions which probably show less ambiguity. However, the reliability figure obtained in the present study still exceeded the requirement for certification in FACS scoring. The certification test requires the coder to score videotape segments for all FACS units, and a reliability score of .70 in relation to the authors' criterion scoring is required. Also, as will be discussed shortly, not all of the actions specified by the FACS system were employed as dependent variables in the present study. Scoring reliability figures were generally higher among the subset of AU's retained for further analysis.

Reliabilities for AU/AD onset and offset were calculated separately as:

$$\frac{\text{No. of agreements about the onset (or offset) of an AU or AD}}{\text{Total no. of AU and AD \underline{appearances} agreed upon}}$$

An onset agreement was tabulated if the two coders agreed within .2 seconds of each other on the beginning of an AU/AD apex. An offset agreement was scored if the two coders agreed within .2 seconds of each other on the termination of an AU/AD apex. This .2 second "location" criterion is considerably more conservative than the .5 second criterion regarded as adequate by Ekman and Friesen (1978a). However, the length of the videotape segments being coded, together with the decision to score AU/AD apices versus absolute onset/offset, suggested a more stringent criterion. AU 45 (blink) was omitted from the calculation of onset/offset reliabilities, since the same "location" criteria were implicit in the frequency scoring criteria for this AU (i.e. an agreement on the appearance of AU 45 was scored only if the scorers concurred within .2 seconds on the time of occurence). According to these criteria, overall reliability for AU/AD (apex) onset was .79; reliability for AU/AD offset was .71.

A final reliability figure was calculated for AU/AD intensity scoring. An intensity agreement was scored when the two coders agreed on the strength of an action scored by both of them. Reliability was calculated as:

$$\frac{\text{No. of agreements about the intensity of an AU or AD}}{\text{Total no. of AU and AD } \underline{\text{appearances}} \text{ agreed upon}}$$

Again, this calculation considered only the subset of AU's and AD's for which intensity scoring criteria are specified by FACS. The calculated reliability figure was .68.

The above reliability figures represent means for all AU's and AD's that appeared at least once in the five videotape segments. However, as will be discussed more fully at a later point, only a subset of these actions were retained for preliminary analyses aimed at identifying units associated with pain - those AU's that were less rare and represented the phenomenon of major interest in this study. Frequency, onset, offset, and intensity reliabilities were recalculated for this specific group of AU's. The figures were .82, .78, .73, and .65, respectively. With the exception of the intensity scoring figure, these represent satisfactory levels of intercoder agreement. Preliminary analyses using this smaller group of AU's showed that six of them occurred more frequently during the period of noxious stimulation than during the baseline phase. Frequency scores for these six AU's constituted the dependent measures in further analyses that examined group differences in facial activity during the cold pressor test. The mean frequency scoring reliability for this group of six AU's was .85 - again, a respectable level of intercoder agreement.

Manipulation Checks

As mentioned previously, a post-test questionnaire was completed by each subject prior to debriefing (see Appendix C). Questions 1 through 5 were answered by subjects in all six groups; questions 6 through 8 by subjects in the experimental groups only; and questions 9 and 10 by tolerant and intolerant group subjects in the visual condition only. Except for item 5, these questions required the subject to rate same aspect of her experience on a 7-point scale, anchored at 1 and 7 at the bottom and top, respectively.

Of the ten items on this questionnaire, only questions 2 and 5 were not intended as manipulation checks: They were included as dependent measures of sensitivity to the noxious stimulus. As such, they were included as dependent variables in a later analysis.

Subject responses to post-test questionnaire items 1, 3, and 4 were included as dependent measures in a 3 x 2 (Modeling x Cue) Multivariate Analysis of Variance (MANOVA). These items dealt with, respectively, the ease with which the subject was able to rate her discomfort, her awareness of videotaping during the session, and the degree to which this awareness affected her behavior. A fourth dependent measure was also included in this analysis: subject's initial rating of discomfort during exposure to the cold pressor test. This variable was included to rule out the possibility that the groups differed from the outset in their reactions to the noxious stimulus. For purposes of analysis, subject ratings were converted to numerical scores in accordance with the scaled values derived by Gracely, McGrath, and Dubner (1979). The same procedure has been used in previous studies (Shapiro & Reeves, 1982; Tursky, Jamner, & Friedman, 1982).

The multivariate omnibus $\underline{F}$ indicated no significant differences among the three modeling conditions on any of these four dependent measures, $\underline{F}$ (8,126) = 0.52, $\underline{p} > .05$. Likewise, the overall tests for the Cue effect, F (4,63) = 0.96, $p > .05$, and Modeling x Cue interaction effect, F (8,126) = 1.23, $p > .05$, were not significant. This analysis is summarized in Appendix G; group means for the dependent measures appear in Table I.

Subject responses to post-test questionnaire items 6, 7, and 8 were included as dependent measures in a 2 x 2 (tolerant, intolerant Modeling x Cue) MANOVA. These items dealt with, respectively, the subject's perception of: a) the model's tolerance of the cold water relative to her own, b) the degree to which her ratings were influenced by those of the model, and c) the degree to which her ratings influenced the model's ratings.

The omnibus F test was significant for the effect of the Modeling variable, F (3,42) = 15.99, $p < .0001$ (See Appendix G). Multiple comparisons were conducted at the .05 level using the Bonferonni (BON) procedure recommended by Ramsey (1980) for the case of two groups measured on p variables. Results of the BON tests showed that the two modeling groups differed significantly in their average response to item 6 of the post-test questionnaire: subjects in the tolerant group rated their partner (the model) higher on the 7-point "tolerance" scale ($\bar{X}$= 5.17, SD = 1.21) than did subjects in the intolerant group ($\bar{X}$ = 3.00, SD = 0.98). The two groups did not differ significantly on items 7 or 8. The overall tests for the Cue effect, F (3,42) = 0.45, $p > .05$, and the Modeling x Cue interaction effect, F (3,42) = 1.49, $p > .05$, were not

Table I

Modeling Group Means and Standard Deviations (in Parentheses) for Manipulation Check Measures

Measure	Visual Condition						Nonvisual Condition					
	Tolerant		Intolerant		Control		Tolerant		Intolerant		Control	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Initial Discomfort Rating [a]	6.77	(2.46)	7.37	(2.47)	5.58	(2.84)	6.29	(3.16)	6.07	(2.37)	8.44	(4.53)
PTQ 1 (Ease of Rating)	3.33	(1.78)	3.08	(1.31)	3.58	(1.51)	3.67	(1.72)	4.00	(1.48)	3.33	(1.78)
PTQ 3 (Awareness of Video)	1.67	(0.98)	2.17	(1.59)	3.17	(2.17)	2.75	(2.01)	2.67	(1.37)	3.00	(1.71)
PTQ 4 (Effect of Video on Behavior)	1.17	(0.39)	1.67	(0.98)	1.75	(1.06)	2.00	(1.60)	1.75	(1.22)	2.25	(1.82)
PTQ 6 (Model's Tolerance)	5.00	(0.95)	3.42	(1.08)	-	-	5.33	(1.44)	2.58	(0.67)	-	-
PTQ 7 (Model's Influence on Subject)	2.08	(1.31)	2.92	(1.38)	-	-	2.75	(1.42)	3.08	(1.78)	-	-

Table I cont'd

Measure	Visual Condition						Nonvisual Condition					
	Tolerant		Intolerant		Control		Tolerant		Intolerant		Control	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
PTQ 8 (Subject's Influence on Model)	2.08	(1.38)	2.50	(1.24)	-	-	2.42	(1.24)	2.50	(1.31)	-	-
PTQ 9 (Opportunity to see Model's Face)[b]	1.11	(0.33)	1.89	(1.36)	-	-	-	-	-	-	-	-
PTQ 10 (Model's Expressiveness)[b]	2.11	(1.45)	4.11	(0.33)	-	-	-	-	-	-	-	-

Note. n= 12 per group, maximum score = 7 (except where indicated); PTQ = post-test questionnaire; PTQ items 6-8 were answered by experimental subjects only, items 9 and 10 by visual experimental subjects only.

[a] Maximum Score = 44.8

[b] n= 9 per group

significant. Group means for the dependent measures in this analysis appear in Table I.

The data from items 9 and 10 of the post-test questionnaire were analyzed using Hotelling's T^2 procedure. Item 9 asked subjects in the tolerant- and intolerant-visual groups to estimate how much opportunity they had to observe the model's facial expression during the cold pressor test. Item 10 asked them to rate their partner's facial expressiveness relative to their own. Six cases (three from each group) were deleted from the analysis because of missing data values.

The omnibus multivariate $\underline{F}$ was significant, $\underline{F}$ (2,15) = 8.26, $\underline{p} < .005$, indicating overall group differences (see Appendix G). Results of individual comparisons at the .05 level using the BON procedure showed no differences between the groups on item 9. The groups did differ, however, in their average response to item 10: subjects in the intolerant condition rated the model as significantly more expressive than did subjects in the tolerant condition (see Table I).

<u>Pain sensitivity: Self-report indices</u>

A 3 x 2 (Modeling x Cue) Multivariate Analysis of Covariance (MANCOVA) was carried out to examine group differences on seven measures of sensitivity to the noxious stimulus used in this study.

Four of these dependent measures related to subjects' ratings of discomfort during the cold pressor test. Three of these four measures were chosen to correspond with videotape segments 3, 4, and 5 chosen for

FACS analysis: magnitude of fifth rating (cf. segment 3: 40 to 50 second period of exposure), number of ratings made before selecting a rating of 7 or higher on the scale (cf. segment 4: 10 seconds prior to a rating of seven or higher on the scale), and magnitude of final rating before terminating cold pressor exposure (cf. segment 5: 10 second period prior to withdrawal of the hand from the cold water bath). Again, subject ratings were assigned their appropriate numerical weights (Gracely, McGrath, & Dubner, 1979) for purposes of analysis. The fourth "rating" dependent measure was number of ratings made before selecting the highest rating (12) on the self-report scale. The purpose of this measure was to examine group differences in rate of ascent to the highest level on the rating scale.

A fifth dependent measure, total time (seconds) of exposure to the cold pressor test, was included as a measure of "pain tolerance". The last two dependent measures were items 2 and 5 of the post-test questionnaire (see Appendix C). The former asked subjects to rate the pain of the cold pressor test on a 7-point scale, the latter to estimate their time of exposure to the noxious stimulus.[3]

[3] Subjects estimated time of exposure was converted to a discrepency proportion:

$$\frac{\text{Estimated time of exposure} - \text{Actual time of Exposure}}{\text{Actual time of exposure}}$$

This was done to correct for the greater margin of estimate error associated with longer exposure times.

An eighth variable, magnitude of initial rating of discomfort during the cold pressor test, was included as a covariate in the analysis because it was found to correlate significantly with four of the seven dependent measures: magnitude of fifth rating ($r = 0.50$, $p < .001$), number of ratings before selecting a rating of 7 or higher ($r = -0.45$, $p < .001$), number of ratings before selecting rating 12 ($r = -0.30$, $p < .01$), and post-test questionnaire item 2 ($r = 0.26$, $p < .05$).

The overall F test was significant for the effect of the Modeling variable, F (14, 118) = 5.09, $p < .001$, and the Cue variable, F (7, 59) = 2.87, $p < .05$. The test for the Modeling x Cue interaction effect, F (14, 118) = 1.54, $p > .05$, was not significant (see Appendix H).

To determine which group differences on which dependent measures were responsible for the overall Modeling effect, multiple comparisons were conducted at the .05 level using the Tukey - Bonferonni (T-B) procedure recommended by Ramsey (1980) for the case of more than two groups measured on p variables. These comparisons indicated that modeling group differences on all dependent measures <u>except</u> post-test questionnaire item 5 contributed to the overall effect (see Table II). On all of these dependent measures except pain tolerance (i.e. total time

Table II

Modeling Condition: Covariate Adjusted Group Means and Standard Deviations (in Parentheses) for Self-Report Indices of Pain Sensitivity

Measure	Tolerant		Intolerant		Control	
	M	SD	M	SD	M	SD
Fifth Rating (max. = 44.8)	9.86	(3.72)	18.97	(11.73)	19.26	(13.92)
Number of Ratings Below 7th Descriptor (max. = 36)	12.79	(14.05)	3.49	(3.01)	4.47	(5.93)
Final Rating (max. = 44.8)	27.17	(16.25)	42.42	(7.35)	40.33	(8.31)
Number of Ratings Below 12th Descriptor (max. = 36)	27.55	(11.21)	14.29	(11.06)	20.87	(12.85)
Tolerance - secs. (max. = 365)	322.38	(85.95)	191.44	(105.54)	279.96	(102.06)
PTQ 2 - Post-test rating of pain severity (max. = 7)	5.56	(1.29)	6.25	(0.79)	6.23	(0.94)
PTQ 5 - Estimated exposure time [a]	-0.45	(0.22)	-0.39	(0.32)	-0.39	(0.34)

Note. *n* = 24 per group (Modeling groups are collapsed over Cue Condition); covariate is initial discomfort rating; PTQ = post-test questionnaire.

[a] Expressed as a discrepancy proportion:

$$\frac{\text{estimated exposure time} - \text{actual exposure time}}{\text{actual exposure time}}$$

of exposure to the cold pressor), the tolerant group differed from the other two in the predicted direction, while intolerant and control group scores were not significantly different. On the pain tolerance variable, the intolerant group ($\overline{X}$ = 191.44 sec., SD = 105.54) differed from the other two groups in the predicted direction; the tolerant ($\overline{X}$= 322.38 sec., SD = 85.95) versus control group ($\overline{X}$ = 279.96 sec., SD = 102.06) difference was not statistically significant (see Table II).

Multiple comparisons for the Cue effect were conducted at the .05 level using the BON procedure (Ramsey, 1980). Although the overall trend of the data was suggestive of lower sensitivity and greater tolerance for subjects in the nonvisual Cue condition (see Table III), none of the individual comparisons were significant.

Pain sensitivity: Facial Expression Indices

Reducing the number of dependent variables.

As mentioned previously, each of the five videotape segments selected for analysis was coded for all 64 AU's and AD's specified by the FACS system. Before proceeding with statistical analysis of these data, it was necessary to reduce this large quantity of dependent measures to a manageable number.

First, all 20 AD's (head and eye position changes, parts of face out of view, etc.) were eliminated, because they were of minimal interest in

Table III

Cue Condition: Covariate Adjusted Group Means and Standard Deviations (in Parentheses) for Self-Report Indices of Pain Sensitivity

Measure	Visual		Nonvisual	
	M	*SD*	*M*	*SD*
Fifth Rating (max. = 44.8)	15.86	(10.89)	16.21	(12.32)
Number of Ratings Below 7th Descriptor (max. = 36)	6.04	(8.32)	7.80	(11.34)
Final Rating (max. = 44.8)	39.20	(11.25)	34.08	(14.57)
Number of Ratings Below 12th Descriptor (max. = 36)	19.44	(12.46)	22.36	(13.24)
Tolerance - secs. (max. = 365)	237.04	(115.93)	292.15	(100.85)
PTQ 2 - Post-test rating of pain severity (max. = 7)	5.99	(1.16)	6.04	(0.98)
PTQ 5 - Estimated exposure time[a]	-0.37	(0.27)	-0.45	(0.31)

Note. *n* = 36 per group (Cue groups are collapsed over Modeling condition); covariate is initial discomfort rating; PTQ = post-test questionnaire.

[a] Expressed as a discrepency proportion:

$$\frac{\text{estimated exposure time} - \text{actual exposure time}}{\text{actual exposure time}}$$

the present study. Then, infrequently occurring AU's were removed from further consideration. The inclusion criterion for AU frequency was an average of at least two occurrences of an AU per segment for all the 72 subjects. An AU was eliminated if it showed a lower average frequency than this when occurrences for all 72 subjects were summed over each segment. Of the 64 scorable actions specified by the FACS system, 21 remained after these exclusion criteria were applied.

One final procedure was implemented to further reduce the number of dependent measures: AU's involving similar muscle movements and similar appearance changes (according to Ekman & Friesen, 1978a) were collapsed together. The result was 15 dependent measures (see Table IV).

Scoring reliabilities were recalculated for these 15 categories of facial movement. Reliability for frequency scoring was .82; for scoring apex onset, .78; and for scoring apex offset, .73. Reliability for intensity scoring was calculated from data on AU's 5, 10, and 12 only: AU 20 was not included because it had been collapsed together with AU 14. The reliability figure for intensity scoring was .65.

Preliminary analyses: Baseline versus cold pressor exposure.

A series of repeated measures Hotelling's T^2 analyses was used to compare the 10-second baseline videotape segment with the data obtained during exposure to the cold pressor test. The purpose of these analyses was to determine which of the 15 dependent measures of facial

Table IV

Action Unit (AU) Categories Remaining after Application of Exclusion Criteria and Collapsing: Frequency, Duration Means and Standard Deviations (in Parentheses) for Baseline and Cold Pressor Periods

AU	Frequency Data				Duration Data[a]			
	Baseline		Cold Pressor		Baseline		Cold Pressor	
	M	SD	M	SD	M	SD	M	SD
1/2 (inner/outer brow raise)	0.125	(0.529)	0.241	(0.770)	0.155	(0.852)	0.259	(1.233)
4 (brow lower)[c]	0.014	(0.118)	0.106	(0.338)	0.005	(0.044)	0.094	(0.489)
5 (upper lid raise)	0.014	(0.118)	0.130	(0.400)	0.005	(0.039)	0.092	(0.410)
6/7 (cheek raise /lids tight)[c]	0.042	(0.201)	0.264	(0.562)	0.100	(0.669)	0.657	(1.931)
10 (upper lip raise)[c]	0.000	(0.000)	0.125	(0.371)	0.000	(0.000)	0.402	(1.632)
12 (lip corner pull)	0.153	(0.362)	0.449	(0.673)	0.661	(2.047)	1.325	(2.545)
14/20 (dimpler/ lip stretch)[c]	0.208	(0.502)	0.282	(0.536)	0.260	(1.233)	0.338	(0.930)
17 (chin raise)[c]	0.000	(0.000)	0.106	(0.364)	0.000	(0.000)	0.130	(0.815)

Table IV cont'd

AU	Frequency Data				Duration Data[a]			
	Baseline		Cold Pressor		Baseline		Cold Pressor	
	M	SD	M	SD	M	SD	M	SD
18 (lip pucker)	0.000	(0.000)	0.051	(0.241)	0.000	(0.000)	0.079	(0.697)
19/37 (tongue show/lip wipe)	0.042	(0.201)	0.120	(0.366)	0.005	(0.027)	0.056	(0.215)
24 (lip press)[c]	0.014	(0.118)	0.074	(0.280)	0.017	(0.147)	0.204	(1.034)
25 (lips part)[c]	0.069	(0.256)	0.417	(0.684)	0.426	(1.958)	0.955	(2.176)
26/27 (jaw drop/ mouth stretch)	0.042	(0.201)	0.356	(0.694)	0.013	(0.071)	0.383	(1.193)
28 (lip suck)	0.028	(0.165)	0.130	(0.376)	0.030	(0.197)	0.314	(1.233)
43/45[b] (eyes closed/blink)[c]	2.375	(1.975)	3.120	(2.283)	0.051	(0.433)	0.095	(0.286)

Note. Baseline period = videotape segment 1, Cold Pressor period = mean of videotape segments 2, 3, and 5; *n* = 72 subjects per period.

a Duration scores are presented in seconds.

b For duration data, this category was AU 43 (eyes closed) *alone*.

c Consistent with Hjortsjo's (1969) descriptions of the facial expression of pain.

expression were more evident during exposure to the noxious stimulus. Two approaches were used, a theoretical and an empirical approach. The former employed as dependent measures only those AU categories hypothesized to participate in the facial expression of pain (Hjortsjo, 1969). The latter employed all 15 AU categories, to determine whether any additional facial movements might be involved.

As mentioned previously, four 10-second segments corresponding to cold pressor exposure were selected from each subject's videotape data. An average of these "cold pressor" segments provided substantially more degrees of freedom in the error term of the analysis: Therefore, each T^2 analysis in this section compared facial action scores in the baseline videotape segment with the <u>mean</u> of scores from "cold pressor" segments 2, 3, and 5. Segment 4 was omitted from this average for two reasons: First, for 10 of the 72 subjects, Segment 4 data overlapped with data from other segments (i.e. segment 4 overlapped with segment 2 in three cases; with segment 3 in seven other cases). Moreover, Segment 4 data were absent in five other cases where subjects endured the maximum period of cold pressor exposure without advancing past a rating of 6 on the self-report panel. There were two reasons for omitting segment 4 entirely from the "cold pressor" average rather than deleting these 15 cases list-wise: a) the latter strategy would have left fewer degrees of freedom in the analysis "error term", and b) these 15 cases were not evenly distributed among the experimental groups (i.e. the majority were tolerant group subjects).

The frequency scores for the AU categories were analyzed first. A repeated measures Hotelling's T^2 analysis was carried out using a subset of eight of these units as dependent measures; these were the AU categories consistent with Hjortsjo's (1969) predictions about the facial movements involved in the expression of pain (see Table IV). The overall test was significant, F (8, 208) = 5.04, $p < .0001$ (see Appendix I). Multiple comparisons at the $\alpha = .05$ level using the BON procedure (Ramsey, 1980) indicated that four of these eight AU categories were more frequent in the cold pressor segments than in the baseline period: AU 6/7 (cheek raise/lids tight), AU 10 (upper lip raise), AU 25 (lips part), and AU 43/45 (eyes closed/blink). These results are presented in Table V.

A second repeated measures T^2 analysis, including as dependent measures all 15 AU categories, was carried out to determine whether any facial actions not consistent with Hjortsjo's predictions were involved. Again, the overall test was significant, F (15,201) = 3.93, $p < .0001$ (see Appendix I). BON comparisons at the .05 level revealed significant differences on five dependent measures, two of which had not been included in the previous analysis: AU 12 (lip corner pull) and AU 26/27 (jaw drop/mouth stretch). These results appear in Table V.

The preceding two analyses were repeated using AU duration scores for the dependent measures. AU categories for the duration score analyses were the same as for the frequency score analyses, with one exception: AU 43/45 was replaced by AU 43 alone. The rationale for this

Table V

AU Categories Appearing More Frequently During Cold Pressor Exposure: Frequency Means and Standard Deviations (In Parentheses) for Baseline and Cold Pressor Periods

AU	Baseline		Cold Pressor		Baseline/Cold Pressor Means Significantly* Different in:
	M	SD	M	SD	
6/7 (cheek raise /lids tight)[a]	0.042	(0.201)	0.264	(0.562)	Both Analyses
10 (upper lip raise)[a]	0.000	(0.000)	0.125	(0.371)	Both Analyses
12 (lip corner pull)[b]	0.153	(0.362)	0.449	(0.673)	Analysis 2
25 (lips part)[a]	0.069	(0.256)	0.417	(0.684)	Both Analyses
26/27 (jaw drop/ mouth stretch)[b]	0.042	(0.201)	0.356	(0.694)	Analysis 2
43/45 (eyes closed/blink)[a]	2.375	(1.975)	3.120	(2.283)	Analysis 1

Note. Baseline period = videotape segment 1, Cold Pressor period = mean of videotape segments 2, 3, and 5; n = 72 subjects per period.

Analysis 1 included frequency scores for AU's consistent with Hjortsjo's (1969) descriptions of the pain expression.

Analysis 2 included frequency scores for all 15 AU's remaining after application of exclusion criteria and collapsing.

a Consistent with Hjortsjo's (1969) descriptions of the facial expression of pain.

b Appeared only in Analysis 2.

$^*p < .05$

change was that AU 45 (blink) is by definition a very discrete movement, so that measuring its duration is meaningless. The overall test in the first duration data analysis, a repeated measures T^2 including as dependent measures the eight AU categories consistent with Hjortsjo's (1969) predictions, was significant, $\underline{F}$ (8,208) = 2.02, $\underline{p} < .05$ (see Appendix I). Without exception, AU duration means were higher for the cold pressor period than for the baseline period (see Table IV). However, multiple comparisons using the BON procedure (alpha =.05) failed to reveal significant differences on any of the individual dependent measures. The same result was found in the second repeated measures T^2, which included duration scores for all 15 AU categories: The overall test was significant, $\underline{F}$ (15,201) = 2.25, $\underline{P} < .01$ (see Appendix I), but multiple comparisons failed to reveal the source of this overall difference.

The intensity scoring data for AU's 5, 10, and 12 were not analyzed. In light of the relatively poor reliability associated with these scores (.65), it was judged unproductive to further add to the experimentwise error rate by analyzing these data.

Group Comparisons.

Group comparisons of facial activity during the cold pressor segments were conducted using frequency scores for the six AU categories found to be significantly more frequent in the cold pressor videotape segments as compared to the baseline segment: AU's 6/7, 10, 12, 25, 26/27, and 43/45. Reliability of frequency scoring was recalculated for these six AU categories; the reliability figure was .85.

A series of 3 x 2 x 2 (Modeling x Cue x Segment) repeated measures MANOVA's was performed using the aforementioned six AU categories as dependent measures. The first two factors in the analysis were the tolerant/intolerant/control and visual/nonvisual dimensions. The third factor was the repeated measures factor: each MANOVA compared the facial activity of the different groups during videotape Segment 2 (initial 10 seconds) with their behavior at a later point of cold pressor exposure (i.e. Segments 3, 4, and 5). This repeated measures factor was included to examine how group differences, and behavior of the sample as whole, changed over the period of cold pressor exposure. These four videotape segments were not combined into a single analysis because they were not selected using a homogeneous sampling rationale. For example, Segment 3 was chosen according to a time criterion (i.e. 40 to 50 second mark of cold pressor exposure), while Segment 4 was selected according to a self-report criterion (i.e. 10 second period prior to a rating of $\geq$ 7 on the scale). Segment 5, the last 10 seconds of cold pressor exposure for each subject, was selected using a behavioral criterion, hand withdrawal, and was independent of either time or self-report criteria. These segments were included in separate analyses to underscore and maintain these conceptual distinctions, with Segment 2 serving as an "anchor" for each analysis.

Segments 2 and 3 were represented in the first 3 x 2 x 2 (Modeling x Cue x Segment) repeated measures MANOVA. The only significant main effect was the Segment effect, F (6,61) = 4.34, $p < .005$; none of the interactions were significant (See Appendix I). Inspection of the means indicated an overall decline in the incidence of these AU's between Segment 2 and Segment 3 (see Table VI). BON comparisons (Ramsey, 1980) for the Segment effect (.05 level) revealed a statistically significant difference on one of the six dependent measures: AU 26/27 occurred more frequently in Segment 2 than in Segment 3. The difference between Segments 2 and 3 would appear to be a function of relaxation of the musculature in the mouth area.

A second 3 x 2 x 2 MANOVA contrasted videotape segments 2 and 4. Three cases were deleted because data from Segment 2 overlapped with data from Segment 4; another five cases were dropped because of missing values. The only significant main effect in the analysis was the Segment effect, F (6,53) = 2.70, $p < .05$; there were no significant interactions (See Appendix I). Again inspection of the means indicated an overall tendency for the AU's to be less frequent in Segment 4 than in Segment 2 (see Table VI). Multiple comparisons for the Segment effect (.05 level) using the BON procedure, however, failed to reveal any statistically significant differences on the individual dependent measures.

Table VI

AU Categories Associated with Cold Pressor Exposure: Frequency Score Means and Standard Deviations (in Parentheses) for Videotape Segments 2 - 5

AU	Segment 2		Segment 3		Segment 4[a]		Segment 5	
	M	SD	M	SD	M	SD	M	SD
6/7 (cheek raise /lids tight)	0.403	(0.705)	0.250	(0.550)	0.359	(0.627)	0.139	(0.348)
10 (upper lip raise)	0.208	(0.442)	0.083	(0.325)	0.078	(0.270)	0.083	(0.325)
12 (lip corner pull)	0.597	(0.685)	0.500	(0.732)	0.547	(0.775)	0.250	(0.550)
25 (lips part)	0.569	(0.766)	0.375	(0.680)	0.359	(0.675)	0.306	(0.573)
26/27 (jaw drop/ mouth stretch)	0.542	(0.821)	0.222	(0.587)	0.297	(0.582)	0.306	(0.620)
43/45 (eyes closed/blink)	2.847	(2.256)	3.500	(2.379)	3.125	(2.059)	3.014	(2.191)

Note. n = 72 per segment (except where indicated).

a n = 64 (segment 4 was not available for five subjects; three more cases were deleted due to overlap with segment 2).

The final 3 x 2 x 2 repeated measures MANOVA included videotape Segments 2 and 5. Once again, the only significant main effect was the Segment effect, F (6,61) = 4.70, $p < .001$, and all interaction effects were nonsignificant (See Appendix I). Consistent with the preceding two analyses, the AU's tended to be less frequent in Segment 5 than in Segment 2 (see Table VI). BON comparisons at the .05 level revealed significant differences for the Segment effect on two of the dependent measures: both AU 6/7 and AU 12 were more frequent during Segment 2 than Segment 5 (i.e. tension of the muscles in the region of the eyes and the lip corners was more pronounced in the earlier segment).

Relationship between self-report and facial expression.

A stepwise multiple regression analysis was performed to examine the relationship between self-report and facial activity in the four "cold pressor" videotape segments selected for analysis. The data for the analysis included Segments 2-5 for all 72 subjects, excepting Segment 4 data that overlapped with data from Segments 2 or 3. The predictor variables were the six AU frequency categories found to discriminate between baseline and cold pressor exposure: AU's 6/7, 10, 12, 25, 26/27 and 43/45. The criterion was the magnitude of subject self-report associated with each of the four videotape segments (i.e. the magnitude of the rating provided by a subject at the end of the 10-second period corresponding to a particular segment). Self-reports were converted to numerical scores (Gracely, McGrath, & Dubner, 1979) for purposes of analysis.

The regression coefficient was significant only at the first "step" of the analysis, F (1,271) = 3.91, $\underline{p} < .05$, at which stage only AU 6/7 had entered the equation (see Appendix I). The correlation between AU 6/7 and self-report magnitude was -0.12; this relationship is presented along with other rating/AU correlations in Table VII.

It was speculated that the correlation between self-report and facial expression in the overall sample might have been obscured by the Modeling factor. To rule out this possibility, the analysis was repeated using data from Segments 2 - 5 for the control groups only (n = 24). In this case, there was no relationship between self-report and facial expression: the regression coefficient was nonsignificant even at the first step of the analysis, $\underline{F}$ (1,89) = 1.71, $\underline{p} > .05$ (see Appendix I).

Intercorrelations among "Pain" AU's

A correlation matrix was constructed to investigate the relationships among the AU categories found to occur more frequently during cold pressor exposure (see Table VIII). The data for this analysis were the AU frequency scores from videotape Segments 2 - 5 for the entire sample (n = 72), excepting Segment 4 data redundant with scores from Segments 2 or 3.

With the exception of AU 43/45, each AU category showed a significant positive correlation with every other AU category. AU 43/45 showed a significant positive correlation with only one other AU category (AU 6/7), and this relationship was quite weak (r = 0.13, $p < .05$).

Table VII

Correlations Between Discomfort Ratings and Facial Activity During Cold Pressor Exposure

AU	Rating
6/7	-0.12*
10	-0.07
12	-0.08
25	-0.07
26/27	0.05
43/45	0.00

Note. Data are self-reports and AU frequency scores from segments 2-5 for all subjects (*n* = 72), excepting segment 4 data overlapping with data from segments 2 or 3 (overall *n* = 273 cases).

*$p < .05$

Table VIII

Correlations Among AU Categories Associated with
Cold Pressor Exposure

	AU 6/7	AU 10	AU 12	AU 25	AU 26/27	AU 43/45
AU 6/7		0.13*	0.20***	0.18**	0.22**	0.13*
AU 10			0.13*	0.18**	0.11*	0.05
AU 12				0.33***	0.23***	-0.20***
AU 25					0.20***	-0.05
AU 26/27						0.00
AU 43/45						

Note. Data are AU frequency scores from segments 2 - 5 for all subjects (n = 72), excepting segment 4 data overlapping with data from segments 2 or 3 (overall n = 273 cases).

$^{*}p < .05$

$^{**}p < .01$

$^{***}p < .001$

Discussion

The findings for self-report and facial indices of the cold pressor pain experience are discussed separately, followed by a discussion of relationships between the measures, a summary, and an analysis of implications for future research.

Self-Report Measures

A number of studies have shown that verbal report and other indices of the experience of pain can be influenced by social modeling (e.g. Craig, 1978a; Craig, Best, & Best, 1978; Craig, Best, & Ward, 1975; Craig & Coren, 1975; Craig & Prkachin, 1978). These studies have typically employed a source of relatively acute pain (i.e. electric shock) whose intensity usually has been increased over trials. The present study examined whether these findings could be replicated using the cold pressor test, a more prolonged noxious stimulus whose objective parameters do not change over time. In addition, the cold pressor has been described as provoking pain that more closely approximates deep clinical pain (Turk, Meichenbaum, & Genest, 1983; Wolff, 1978).

In general, it was found that subjects' self-reports of pain-induced affective discomfort and willingness to tolerate cold pressor exposure matched the behavior modeled by confederates. Subjects paired with a tolerant model made significantly more ratings below the highest descriptor on the ascending self-report scale than either intolerant- or control-group subjects. Their mean final rating of subjective distress was also significantly lower than that reached by intolerant and control subjects. This was true despite the fact that subjects paired with an intolerant model endured the cold pressor test for a substantial and significantly shorter period of time than did subjects in the other two groups. Tolerant- and control-group subjects did not differ on the tolerance measure (i.e. length of exposure) but the fact that they did differ with respect to their average final rating - the controls reached a higher level (see Table II) - suggests that this may have been due to a ceiling effect: the six minute maximum exposure time was too short to enable the tolerant subjects to "outlast" the controls.

Differences in self-report among the groups were evident at an early stage of cold pressor exposure: By the fifth self-report, tolerant-group subjects were rating their discomfort at a significantly lower level than either intolerant- or control-group subjects. Also, the tolerant-group subjects took comparatively longer to exceed a rating of 6 on the 12-point self-report scale, just as they took comparatively longer overall to approach the top end of the scale. The fact that the groups were initially equivalent in terms of rating magnitude lends further credence to the conclusion that these later differences were due to the modeling manipulation.

Tolerant-group subjects also gave a lower average global rating of the cold pressor pain on item 2 of the post-test questionnaire. This finding indicates that tolerant-group subjects not only provided lower ratings of discomfort during the cold pressor test, they recalled the experience afterwards as having been less painful. One might also have expected tolerant-group subjects to underestimate cold pressor exposure time to a greater extent than intolerant or control subjects (controlling, of course, for differences in actual exposure times), since the former rated the experience as less stressful. Subjects in the three groups, however, uniformly underestimated exposure time (post-test questionnaire Item 5). Apparently, this "sensitivity" measure was too indirect to yield group differences comparable to those found with the other dependent measures.

The aforementioned group differences were not attributable to differential ease of rating or reactivity to videotaping. Manipulation checks revealed no systematic differences on measures of these extraneous variables (post-test questionnaire Items 1, 3, and 4). Moreover, subject perceptions of the model were consistent with the model's role: tolerant group subjects rated their partner as more tolerant than did intolerant group subjects (post-test questionnaire Item 6). The two groups did not differ, however, in their estimates of the model's influence on their behavior (Item 7) or their own influence on the model's behavior (Item 8). Combining the data for the two groups, one finds that the mean of ratings on Item 8 ($\bar{X}$ = 2.375, SD = 1.265) was not substantially different from the mean on Item 7 ($\bar{X}$ = 2.708, SD = 1.487), suggesting that the modeling influence was quite subtle. Subjects' impressions were that influences between themselves and the models were mutual and similar, thereby failing to observe that the model's impact led to substantially different reaction patterns in those exposed to tolerant or intolerant models.

The Cue Condition (nonvisual, visual) had an overall effect on self-report indices of pain, with group means suggestive of lower sensitivity in the nonvisual condition, but multiple comparisons failed to reveal differences on any individual measure. The overall effect is hence difficult to interpret, particularly as there was no a priori reason to expect such a result: The Cue variable was expected to have its main impact on dependent measures of facial expression.

Facial expressions of pain.

Initial analyses of the FACS data were aimed at specifying AU categories associated with the experience of pain (i.e. AU categories significantly more prominent during exposure to the noxious stimulus as compared to baseline). Six AU categories were found to occur more frequently during the cold pressor period: AU's 6/7 (cheek raise/lids tight), 10 (upper lip raise), 12 (lip corner pull), 25 (lips part), 26/27 (jaw drop/mouth stretch), and 43/45 (eyes closed/blink). Duration measures of facial activity were found to be insensitive to the shift from baseline to cold pressor at the individual AU level. AU intensity scores were not analyzed because of inadequate reliability. This was likely a function of ambiguities in the FACS criteria for differentiating among intensity levels; Ekman and Friesen (1978a), in fact, acknowledge that intensity scoring is "one area where description reliability needs improvement" (p. 33).

Before discussing in greater detail the six "pain" AU categories isolated from the frequency data, three points should be made clear. First, these facial movements were not displayed by all 72 subjects during the cold pressor videotape segments; individual differences in frequency of occurrence were considerable. The mean frequencies and standard deviations for these six AU categories (average of cold pressor segments 2, 3, and 5; $\underline{n}$ = 72) have been presented in Table V. AU 43/45 was the most frequent category, occurring an average of 3.12 times per subject during each of the "cold pressor" segments. As well, it was the only one of the six categories that occurred at least once for every subject during the cold pressor period. However, the mean frequency per segment varied greatly from subject to subject: from 0.33 (one occurrence in the three segments) to 7.67 (23 occurrences in the three segments). The other AU categories were not displayed universally. Instances of AU 10, for example, were observed among only 18 of the 72 subjects during the cold pressor phase (it was totally absent during baseline). AU 12, on the other hand, was displayed at least once by 45 subjects; AU 25 by 44 subjects. AU's 6/7 and 26/27 were between these extremes, occurring in 31 and 38 of the 72 cases, respectively.

This may help to explain why AU duration measures did not discriminate between baseline and cold pressor phases. The error variance associated with the duration scores was generally much larger than that for frequency scores. For all AU categories except AU 43/45, the _frequency_ of occurrence in any segment ranged from zero to four, with most scores falling in the zero to two range. For duration scores, however, the range was zero to 10 seconds (the length of each videotape segment). Although the majority of scores fell at the low end of this range (ie. the modal response was zero), the minority at the upper end was large enough to inflate the error variance dramatically for most AU categories. The corresponding increase in _between_ groups variance was not large enough to compensate for this change in the error term.

Another important point concerns the impact of collapsing certain AU's together to form AU "categories". This was done prior to data analysis to reduce the total number of dependent variables. Three of these collapsed AU categories were among the six frequency measures found to differ in cold pressor versus baseline phases. One side effect of collapsing pairs of AU's together was that the members of a category, for all practical purposes, lose their individual identities. Thus, we cannot say that both AU's 6 and 7 were found to occur more often in the presence of the noxious stimulus. All we can say is that movements of the orbicularis oculi (the muscles orbiting the eyes), resulting in a narrowing of the eye aperture from below, were associated with the presence of a pain-inducing stimulus. Similarly, AU 26/27 refers to an appearance change (mouth opened wide enough so that a gap between the upper and lower front teeth can be seen) involving the action of the pterygoid muscles of the jaw; AU 43/45 to a brief or extended closure of the eyes due to muscle movements (levator palpebrae superioris, orbicularis oculi) in the vicinity of the eye. Although these AU "categories" will henceforth be referred to simply as "AU's", it is important to recognize the departure from the FACS classification.

One final issue is worth mentioning at this stage: Namely, are we entitled to infer from their greater frequency during the cold pressor period that AU's 6/7, 10, 12, 25, 26/27 and 43/45 are facial expressions of pain? We can be reasonably confident that the subjects were experiencing pain during their exposure to the ice cold water. Lewis (1929) observed that phasic vasoconstriction and vasodilation occur during the course of hand immersion in ice water. Since then, various researchers (Carlson, 1962; Krog, et. al., 1960; Kunckle, 1949; Teichner, 1965) have verified that the cyclic vasoconstriction is associated with the perception of pain. Cyclic vasodilation (the Lewis effect), on the other hand, is associated with numbness and diminution of the pain, but does not usually begin until after a substantial period of exposure - in most cases, between 270 and 400 seconds (Teichner, 1965), although some subjects do not manifest it at all. In the present study, subject self-reports corresponding to videotape segments 2, 3, and 5 reflected considerable discomfort, with the magnitude of the mean distress rating (max. = 44.8) increasing over segments (Segment 2: $\bar{X} = 6.75$, SD = 3.10; Segment 3: $\bar{X} = 16.03$, SD = 11.55; Segment 5: $\bar{X} = 36.64$; SD = 13.15).

If the presence of the noxious stimulus had been the only variable differentiating the cold pressor and baseline phases, we could infer with a high degree of confidence that changes in facial expression were occurring as a function of the pain experience. However, the subjects were also responsible for providing ratings of discomfort during the cold pressor test. This decision-making requirement may have affected their facial expressions to an unknown degree. Post-test questionnaire Item 1 asked subjects to estimate (on a 7-point scale) how difficult it was for them to rate their discomfort during the cold pressor test. The mean response to this item was 3.50, suggesting that most subjects did not find the rating requirement overly demanding. Although the relationship between task complexity and facial expression has not been determined, one might speculate that an undemanding task would provoke few nonverbal signs of cogitation. Nevertheless, one cannot dismiss entirely the influence of this extraneous factor. Also, it is possible that the AU's may have to some extent reflected psychological states or adaptive reactions (e.g. orienting behavior, postural adjustments, nonaffective arousal, emotional experience) that were specific to the noxious stimulus and situation, and perhaps not invariably associated with pain. For the sake of economy of notation, this paper has referred to AU's 6/7, 10, 12, 25, 26/27, and 43/45 as "pain AU's". One should bear in mind, however, the inferential leap involved here.

Only four of the six pain AU's identified in the present study were consistent with Hjortsjo's (1969) description of the pain expression: AU's 6/7, 10, 25, and 43/45. The other two (AU's 12 and 26/27) were clearly inconsistent with his description. Hjortsjo said that "the angle of the mouth is strongly pulled downwards- outwards and therefore gives the impression that the mouth opening shows a clearly downwards directed concavity" (p. 84); AU 12 (lip corner puller) involves just the opposite - an upward movement of the lip corners, giving the mouth an upwards directed concavity. Hjortsjo also described the teeth as clenched during the expression of pain; AU 26/27, however, involves dropping the jaw or stretching the mouth open such that the teeth are parted. In addition, the present study failed to identify other pain AU's that would be expected on the basis of Hjortsjo's predictions - most notably AU's 4 (brow lower), 9 (nose wrinkle), 15 (lip corner depress), 17 (chin raise), 20 (lip stretch), 23 (lip tight), and 44 (squint).

However, Hjortsjo's (1969) description of the pain expression was not based on direct observations of people in pain. He asked actors to mimic facial expressions of pain, and he derived a "prototypic" pain expression from his observations. One might expect some departure from this facial configuration among subjects experiencing prolonged discomfort in response to a real noxious stimulus. In addition, Hjortsjo instructed his actors to mimic a facial expression corresponding to "physically hurt, tormented"; the resulting facial expressions were more likely representative of behavior at an extreme level of subjective distress. One cannot be sure whether subjects in the present study experienced such intense pain as a function of cold pressor exposure or even whether commonplace or clinical pain is often of this severity.

Pain AU analyses.

The six pain AU's identified in the present study were used as dependent variables in three further sets of analyses. The first set was directed at determining whether facial expressions of pain were systematically influenced by the two independent variables in the study (Type of Modeling, Cue Condition), or differed at various points during cold pressor exposure (the Segment factor). Three analyses were performed, examining group differences in segments 2 and 3, segments 2 and 4, and segments 2 and 5, respectively. The two independent factors (Modeling, Cue) had no effect on facial expression, either singly or interactively. Only the repeated measures variable "Segment", had any effect: certain pain AU's occurred more frequently during segment 2 than in later segments.

Further analyses examined the relationship between self-reported discomfort and frequency of pain AU's. When the entire sample ($\underline{n}$ = 72) was considered as a group, only one isolated facial action (AU 6/7) was found to correlate significantly with self-report, and the relationship was small and negative (r = -.12). When the control groups ($\underline{n}$ = 24), presumably free of modeling influences, were considered alone, there was no linear combination of pain AU's that correlated significantly with self-report.

These findings were unexpected. One would have anticipated greater facial expressive activity over exposure time and with increasing self-reported distress. From this perspective, tolerant-modeling subjects should have been less expressive than either intolerant or control subjects, particularly in segments 3 and 5 where discomfort ratings were significantly lower among the former. Also, studies of vicarious modeling (e.g. Vaughan and Lanzetta, 1980) lead one to expect that subjects in the visual Cue Condition should have tended more to conform to the behavior of the model. In other words, a Modeling x Cue interaction effect was anticipated: tolerant-group subjects should have been even less facially expressive in the visual condition; intolerant subjects, <u>more</u> expressive; and controls similarly expressive in both Cue Conditions (since the confederate was inactive in each case).

The absence of any Modeling x Cue effect could be attributed quite simply to the fact that the Cue manipulation was probably too indirect. At the end of the cold pressor test, subjects in the visual experimental conditions (tolerant, intolerant) were asked to rate on a 7-point scale how much opportunity they had during the session to observe their partner's facial expression (post-test questionnaire Item 9).The group difference in average response to this item was not statistically significant; the average rating for the two groups combined was 1.50 (SD = 1.04). This suggests quite strongly that "visual" subjects rarely utilized their opportunity to glance over at the model's expression. This is perhaps not surprising when one considers the demands of the rating task, which required subjects to orient toward the panel in front of them (recall that the subject and model were seated side by side). In contrast, it has been suggested that there is strong inherent attraction to opportunities to observe others in distress (Craig, 1978b). Despite the fact that "visual" subjects as a group spent little time looking at the model during the cold pressor test, tolerant-group subjects rated their partner as less facially expressive than did intolerant-group subjects (post-test questionnaire Item 10). It is possible that tolerant-group subjects <u>inferred</u> that their partner was less facially expressive because of the model's lower discomfort ratings.

One might interpret the absence of Modeling group differences in facial expression as further evidence that the modeling manipulation reduced the severity of distress in subjects exposed to a tolerant model - i.e. tolerant subjects, despite a comparably greater length of exposure to the cold pressor, did not display greater facial distress during videotape segments 4 and 5. However, other results do not support the assumption that facial expression discloses pain severity. The frequency of occurrence of the six pain AU's did not increase as a function of either exposure time or magnitude of self-reported discomfort: if anything, facial expressive activity decreased over exposure time and with mounting reports of distress. Had the relationship between facial expression and self-reported discomfort been positive, subjects in the tolerant group might have displayed fewer occurrences of the pain AU's than subjects in the other two groups. Given the large individual differences in pain expression, however, it is unclear whether such between-group differences would be significant in relation to the error variance.

How can one account for the observed relationship between self-report and facial indices of the pain experience? To summarize and expand on what has already been said: The six AU's associated with the presence of the noxious stimulus generally occurred most often during the initial stage of cold pressor exposure (i.e. segment 2). Excepting AU 43/45, the mean frequencies of these dependent measures were in all cases lower during segments 3, 4, and 5: the differences were statistically significant for AU's 6/7, 12, and 26/27. Also correlations between pain AU frequency and magnitude of self-report for the sample as a whole

($\underline{n}$ = 72) were generally negative, although only one AU (AU 6/7, r = -0.12) contributed to a significant regression equation.

These findings are counter-intuitive: One might have expected subjects to be more facially expressive as pain severity mounted over cold pressor exposure time, and self-reports of discomfort increased. One interpretation would be that facial activity is most salient at the beginning of an encounter with a noxious stimulus. The initial response to noxious stimulation probably includes startle, orienting behavior, and adjustive coping behavior, as well as expressions of pain and affective discomfort. These responses become less functional over time and tend to habituate. This has some important implications. First, the initial reaction to a noxious stimulus may include some facial expressive behaviors that do not appear later on during exposure. Also, if facial activity is most salient upon first exposure, the correlation between subjective distress and facial expression should be most highly positive at this point; as the nonverbal reaction habituates over exposure time, facial expressive behavior becomes a poorer index of the pain experience. Indeed, we have seen that facial activity tends to diminish as exposure time and self-reports of discomfort increase.

To test these hypotheses about the initial reaction to noxious stimulation, some of the AU frequency data analyses were repeated using videotape segment 2 scores only (i.e. data from the initial 10 seconds of cold pressor exposure). First, two repeated measures Hotelling's T^2 analyses were performed, each comparing AU frequencies in segment 2 with occurrences during baseline (Segment 1). The first T^2 analysis included as dependent measures the eight AU categories (of the original 15) consistent with Hjorstjo's (1969) descriptions of the pain expression (see Table IV). The overall test was significant, $\underline{F}(8,64) = 5.64$, $\underline{p} < .0001$. Multiple comparisons at the .05 level using the BON procedure (Ramsey, 1980) revealed significant differences on three of the eight dependent variables - AU's 6/7 (cheek raise/lids tight), 10 (upper lip raise), and 25 (lips part) - with mean frequencies higher in segment 2 than baseline (see Table IX). The second repeated measures T^2 analysis incorporated all original 15 AU categories as dependent measures. Again, the overall test was significant, $\underline{F}\ (15,57) = 5.48$, $\underline{p} < .0001$. Individual comparisons using the BON procedure revealed significant differences on six of the 15 AU categories: the three AU's identified in the previous analysis (6/7, 10, and 25) plus AU's 5 (upper lid raise), 12 (lip corner pull), and 26/27 (jaw drop/mouth stretch). Again, as one can see from inspecting Table IX, all six AU's occurred more frequently in segment 2 than in baseline.

These findings provide some support for the hypothesis that facial expressive behaviors at the onset of noxious stimulation may differ somewhat from those occurring at later points. AU 5 (upper lid raise), which was significantly more frequent during segment 2 than baseline, rarely occurred in segments 3, 4, and 5. This facial movement, which involves a raising of the upper eye lids (as opposed to eye brows), is inconsistent with Hjortsjo's (1969) description of the pain expression: He says that "the cover fold of the upper eyelid is pressed downwards" (p. 83). There is some evidence (e.g. Ekman, Friesen, & Tomkins, 1971) that this particular facial movement may participate in a

Table IX

AU Categories Remaining after Application of Exclusion Criteria and Collapsing: Frequency Means and Standard Deviations (in Parentheses) for Videotape Segments 1 and 2

AU	Segment 1		Segment 2	
	M	SD	M	SD
1/2 (inner/outer brow raise)	0.125	(0.529)	0.333	(0.979)
4 (brow lower)[a]	0.014	(0.118)	0.125	(0.373)
5 (upper lid raise)	0.014	(0.118)	0.375	(0.615)
6/7 (cheek raise/ lids tight)[a]	0.042	(0.201)	0.403	(0.705)
10 (upper lip raise)[a]	0.000	(0.000)	0.208	(0.442)
12 (lip corner pull)	0.153	(0.362)	0.597	(0.685)
14/20 (dimpler/lip stretch)[a]	0.208	(0.502)	0.250	(0.524)
17 (chin raise)[a]	0.000	(0.000)	0.139	(0.421)
18 (lip pucker)	0.000	(0.000)	0.083	(0.278)
19/37 (tongue show/ lip wipe)	0.042	(0.201)	0.097	(0.298)
24 (lip press)[a]	0.014	(0.118)	0.069	(0.306)
25 (lips part)[a]	0.069	(0.256)	0.569	(0.766)
26/27 (jaw drop/ mouth stretch)	0.042	(0.201)	0.542	(0.821)
28 (lip suck)	0.028	(0.165)	0.056	(0.231)
43/45 (eyes closed/ blink)[a]	2.375	(1.975)	2.847	(2.256)

Note. Segment 1 = baseline period, Segment 2 = initial 10 seconds of cold pressor exposure; n = 72 subjects per segment.

[a] Consistent with Hjortsjo's (1969) descriptions of the facial expression of pain.

surprise/startle expression; as mentioned earlier, it seems likely that the first response to a noxious stimulus includes a startle component, which dissipates rapidly. AU 43/45, which was found in an earlier analysis to discriminate between baseline and the mean of cold pressor segments 2, 3, and 5, did not discriminate between baseline and segment 2 alone. This may be because the baseline/segment 2 analyses, having fewer degrees of freedom in the error term, were less powerful. Another factor may have been the relatively high incidence of AU 5 in segment 2: Raising the upper lids (AU 5) is incompatible with brief or sustained closure of the eyes (AU 43/45); these AU's cannot be scored concurrently. Indeed, AU 43/45 was the only one of the "pain AU's" (6/7, 10, 12, 25, 26/27, 43/45) whose mean frequency was lower in segment 2 than in later segments, although the differences were not statistically significant.

To test the hypothesis that the correlation between subjective distress and facial expression should be most highly positive at the onset of noxious stimulation, a stepwise multiple regression analysis was performed. The predictor variables were the six AU frequency categories found to discriminate between baseline and videotape segment 2 alone: AU's 5, 6/7, 10, 12, 25, and 26/27. The criterion was the magnitude of subject self-report associated with segment 2, that is, the appropriate numerical score (cf. Gracely, McGrath, & Dubner, 1979) for the rating provided by a subject at the end of the 10-second period corresponding to segment 2. A significant regression equation was derived, F (4,67) = 2.59, $p < .05$ (see Appendix I). The magnitude of the multiple R was .37. Four variables participated in the regression equation: In descending order of weight, these were AU's 26/27, 6/7, 12 and 5. The correlation between each of the six predictor variables and self-report was either positive or near zero (see Table X). This result contrasts with that of an earlier regression analysis, which employed data from segment 2, 3, 4, and 5; here, only one variable (AU 6/7) contributed to a significant regression equation, and the relationship between AU frequency and self-report was negative. It seems that normative relationships between self-reported discomfort and facial expressive behavior may be most clear during the initial phase of prolonged noxious stimulation. Although subjective discomfort (indexed by self-report) mounts over exposure time, facial indices of discomfort do not correspondingly increase: They tend to peak early, and then dissipate.

There is, however, another explanation for the poor relationship between exposure time and increasing self-report on one hand, and facial expressive behavior on the other. The findings lead one to question the assumption made at the initiation of this study, as in virtually all other studies using cold pressor methodology (e.g. Anderson, Jamieson, & Man, 1974; Hilgard et al., 1967, 1974; Rosenbaum, 1980; Thelen & Fry, 1981), that pain mounts progressively during the cold pressor test. Advances along categorical judgment scales toward reports of greater severity may not occur strictly as a function of mounting discomfort. Subjects may also be responding to components of experimenter demand. For example, in the present study, the experimenter communicated the expectation that pain would increase with exposure time: "The discomfort will increase in intensity as your time in the cold water bath continues

Table X

Correlations Between Discomfort Ratings and Facial Activity During Initial 10 Seconds of Cold Pressor Exposure

AU	Rating
5	0.14
6/7	0.00
10	0.05
12	0.16
25	0.07
26/27	0.31**

Note. Data are self-reports and AU frequency scores from videotape segment 2 for all subjects (n = 72).

**$p < .01$

and you will eventually reach a point at which you no longer wish to go on". Also, the discomfort descriptors were arranged in an ascending fashion on the self-report panel. Thus, it is not clear to what extent subjects were accurately reporting their affective states over the cold pressor period; reports invariably mounted over time, but this may have been largely a product of demand.

There were some early reports on the subjective experience of cold pressor pain which shed some light on this issue. Wolf and Hardy (1941) reported that the subjective experience of pain mounts rapidly after immersion of the hand in ice cold water (0°C), with the pain sensation reaching its peak after about 60 seconds of exposure; after this, the pain gradually subsides and disappears entirely after four to five minutes. They state:

> Immersing the hand in water warmer than 18°C. caused no pain, but at 18°C., and slightly below, there was a fleeting deep ache which occurred after the hand had been immersed about 60 seconds, and then promptly ceased. At progressively lower temperatures the pain had its onset sooner and was more intense, always reaching its maximum at about one minute. It then began to subside, and in about four to five minutes was no longer perceived. The character of the pain was aching; there was a feeling as if the hand had been crushed. (Wolf & Hardy, 1941, p. 521)

The same phenomenon has been described less systematically by Lewis (1929) and Teichner (1965).

If facial expressiveness varied as a direct function of subjective discomfort, one might expect more facial activity as subjects approached the one minute mark of cold pressor exposure. There was no evidence for this in the present study. Excepting AU 43/45, all pain AU's were more frequent during segment 2 (initial 10 seconds of exposure) than segment 3 (40 to 50 second mark of exposure), although the difference was statistically significant only for AU 26/27 (see Table VI). Apparently, we cannot conclude that the self-report/facial expressiveness relationship was poor just because subject self-report increased over time in response to demand (versus real changes in subjective discomfort). Indeed, subjects as a group were reporting more discomfort at the end of Segment 3 ($\bar{X}$ = 16.03, SD = 11.55) than at the end of Segment 2 ($\bar{X}$ = 6.75, SD = 3.10). If we are to believe Wolf and Hardy (1941), though, we must assume that this observed increase in self-reported discomfort <u>did</u> reflect a real change in subjective discomfort. Facial activity, however, did not increase correspondingly. Thus, it seems more appropriate to conclude that facial activity does not increase with increasing subjective discomfort; it appears to peak at the onset of noxious stimulation, probably reflecting components of pain, startle, orienting reactions, and instrumental behavior, and then occurs with reduced frequency throughout the period of noxious stimulation.

This is not to say that demand played no role in subjects' mounting reports of discomfort over exposure time. The study by Wolf and Hardy (1941) would lead one to expect that the magnitude of subject discomfort ratings would decline after about the first minute of cold pressor exposure, but this rarely happened. The majority of subjects advanced along the ascending self-report scale in one direction only - toward the top. However, it is still not clear that this behavior was strictly a function of demand. Although Wolf and Hardy noted that cold pressor pain (characterized as "aching") tends to decrease after approximately one minute of exposure, they observed that a "sensation of 'pins and needles'..., occurring shortly after the peak of the aching pain, steadily increased in intensity as the pain decreased" (p. 523). They found that this latter "prickling" sensation could be quite intense and could cause considerable subjective discomfort. Also, like the initial "aching" pain, this sensation tended to mount and then gradually decline "until at the end of 8 to 10 minutes, the immersed hand felt only the cold of the water" (p. 524). Subjects in the present study may have found the cold water to be increasingly intolerable because of the prickling sensation that develops after the initial aching pain has peaked. Firm conclusions are difficult to draw, however, because of methodological limitations of Wolf and Hardy's paper: It was essentially a descriptive study, employing a single subject design, and a primitive, unstandardized self-report index of pain. Also, the role of the Lewis effect (Lewis, 1929) in the phenomena reported by these authors is not clear. More research is needed to determine the extent to which experimenter expectancy and properties of self-report rating scales affect subjects' reports of pain.

One final analysis examined the intercorrelations among the six AU's found to occur more frequently during the cold pressor videotape segments

(2, 3, and 5) than during baseline: AU's 6/7, 10, 12, 25, 26/27, and 43/45. With the exception of AU 43/45, these variables were all positively intercorrelated. AU 43/45 probably showed poor correlations because it occurred so much more frequently than the other AU's; it tended to occur in a segment whether or not any other particular facial movement made an appearance.

Despite the significant positive correlations among all AU categories except AU 43/45, one cannot conclude from these findings that these facial movements comprise a unitary "prototypic" pain expression. First, the correlations were quite low, ranging from +.11 to +.33 (see Table VIII),with a mean of +.19. Second, the observed correlations are not an index of co-occurrence (i.e. the extent to which the occurrences of two or more AU's overlap in time). These correlations simply reflect the extent to which these different facial movements occurred together within the same segment (i.e. within the same 10-second period). This distinction becomes clear when one notes that the correlation between AU's 25 and 26/27, which cannot be scored concurrently, was .20 ($p < .001$); since FACS scoring regulations do not permit these units to be scored at the same time (i.e. as part of the same facial expression), the significant correlation in this case reflects only mutual occurrence within the same 10-second segment. Finally, there is no guarantee that all of the observed correlations are independent of one another. For example, the low significant correlation between AU 6/7 and AU 10 ($r = .13$, $p < .05$) may be due in part or in full to their shared relationship with AU 12 (r equals .20 and .13 respectively). All one can conclude about these correlations is that they represent an upper limit for the co-occurrence of these AU categories. As such, one is more impressed with the independence of these variables than with their degree of interrelationship.

As discussed earlier, it seems likely that facial activity is most evident at the beginning of exposure to a noxious stimulus. From this, one might expect that a unitary expression of pain would most likely manifest itself at this stage. To test this hypothesis, a correlation matrix was constructed to investigate the relationships among the AU categories found to occur more frequently during segment 2 as compared to baseline (see Table XI). The data for this analysis were the AU frequency scores from videotape segment 2 for the entire sample ($\underline{n}$ = 72). Five of the 15 possible correlations were significant; all five were positive. The magnitude of these correlations ranged from .22 to .40, with a mean of .32. Three of these correlations involved relationships between AU 26/27 and other AU's: 5, 6/7, and 12. Interestingly, Ekman, Friesen, and Tomkins (1971) included two facial actions comparable to AU's 26/27 and 5 as components of the facial expression of "surprise" (which may also be interpreted as startle). Similarly, AU 12 participated in three of the five significant correlations: It showed a positive correlation with AU's 6/7 and 25, as well as AU 26/27. This group of AU's may comprise, in addition to a startle component, elements of a facial response to the onset of noxious stimulation. However, the caveats discussed in the preceding paragraph apply here as well. The observed correlations, although decidedly more impressive than those obtained using data from all four cold pressor segments, do not reflect absolute co-occurrence. Even if they did, the magnitude of these

Table XI

Correlations Among AU Categories Associated with Initial 10 Seconds of Cold Pressor Exposure

	AU 5	AU 6/7	AU 10	AU 12	AU 25	AU 26/27
AU 5		0.07	0.02	-0.14	-0.07	0.35**
AU 6/7			0.18	0.25*	0.17	0.40***
AU 10				0.05	0.14	0.11
AU 12					0.36**	0.22*
AU 25						0.15
AU 26/27						

<u>**Note.**</u> Data are AU frequency scores from videotape segment 2 for all subjects ($\underline{n}$ = 72).

*$p < .05$

**$p < .01$

***$p < .001$

correlations would not enable one to talk about a unitary, "prototypic" pain expression. Individual differences in the occurrence and, apparently, co-occurrence of these AU's far outweighed the observed regularities.

Summary and Conclusions

The results of the self-report data analyses replicated findings from other studies of social modeling and pain: Subjects exposed to a tolerant model tended to tolerate more noxious stimulation and reported less pain than subjects exposed to an intolerant model. However, there was no evidence that the groups differed in terms of facial expressive indices of the pain experience. One cannot conclude from these findings, however, that subjects were merely paying "lip service" to the models (i.e. that tolerant subjects were reporting less pain, despite showing equivalent nonverbal signs of discomfort). There was no evidence that facial expressive behavior increased over exposure time and with higher self-reported discomfort, even in the control group which was not subject to the modeling manipulation. It seems unlikely that this phenomenon was entirely an artifact of experimenter demand (i.e. the experimenter communicating the expectancy that discomfort should increase over exposure time; the ascending nature of the self-report scale). Independent evidence (Wolf & Hardy, 1941) suggests that subjects should experience mounting discomfort, at least during the first minute of cold pressor exposure - yet AU's associated with the experience of pain were not more frequent during videotape segment 3 (40 to 50 second mark of cold pressor exposure) than segment 2 (initial 10 seconds of exposure); in fact, they were less frequent.

A more reasonable conclusion is that facial expressive behavior simply does not increase monotonically with mounting subjective discomfort. Facial activity tends to be strongest at the onset of noxious stimulation, apparently reflecting various components of the initial adaptive reaction (startle, pain expression, orienting and coping behavior), and tends to habituate over time. Some facial behaviors (e.g. AU 5) are probably unique to this initial reaction, while others (e.g. AU's 6/7, 10, 12, 25, 26/27) seem to occur with reduced frequency throughout the period of noxious stimulation. AU 43/45 was the only exception to this pattern - it occurred at least as frequently during later periods of exposure (segments 3, 4, and 5) as it did in the initial phase of exposure (segment 2). It is possible that AU 43/45 represents a separate category of reflexive or coping behavior that appears with increased frequency over the entire duration of any ordeal.

Although it was possible to make some normative statements about facial expressions of pain, it is important to recognize that individual differences in facial displays of discomfort were substantial. Of the six AU's found to be discriminating for pain over the entire period of cold pressor exposure, only AU 43/45 was displayed at least once by every member of the 72 subject sample. Other AU's, which did not appear with significantly greater frequency during the cold pressor period (although, in some cases, they did not appear at all during baseline), occurred sporadically during segments 2, 3, 4, and 5. Even during the first 10 seconds of cold pressor exposure, where facial expressive behavior seemed to be most evident, unsystematic observation of subject videotapes showed reactions ranging from complete stoicism to exaggerated displays of discomfort. Evidence for a unitary, prototypic expression of pain was scant, although if such an expression exists, it will probably appear most clearly during the initial phase of exposure to severe noxious stimulation. The results of multiple regression analyses suggested that the correlation between facial expressive behavior and self-reported discomfort may be strongest at the onset of noxious stimulation; similarly, intercorrelations among "pain AU's" were higher at this stage than over a wider sampling of cold pressor exposure periods.

Hjortsjo's (1969) predictions about the components of the "pain expression" received only partial support. Four of the pain AU's identified in the present study (AU's 6/7, 10, 25, and 43/45) were consistent with Hjortsjo's description; the other two (AU's 12 and 26/27) were not. AU 5, which appeared almost exclusively during the firt 10 seconds of exposure and may be part of a startle component (Ekman, Friesen, & Tomkins, 1971), was also inconsistent with Hjortsjo's description. In addition, several prominent components of Hjortsjo's pain expression failed to emerge in the present study. Finally, despite some agreement with Hjortsjo's predictions, there was little evidence that the pain AU's identified here combined with any regularity into a unitary, "prototypic" pain expression. It is possible, though, that a unitary pain expression corresponding more closely to Hjortsjo's description may emerge from studies of severe, acute noxious stimulation.

Hjortsjo based his predictions on the facial expressions of actors simulating severe pain (i.e. "physically hurt, tormented"). Ethical restrictions may limit our opportunity to study such severe levels of discomfort in the laboratory, so that a search for the "prototypic" pain expression may be more fruitfully conducted in naturalistic, clinical settings.

The present study failed to provide an adequate test of the hypothesis that modeling influences on self-reported discomfort should be accompanied by corresponding changes in facial expression. There was no evidence that the facial expressiveness of control subjects varied with their ratings of subjective discomfort, hence it was not surprising that the lower discomfort ratings of tolerant subjects were not accompanied by less facial activity. To the extent that the self-report/facial expressiveness relationship is strongest at the onset of noxious stimulation, a better test of the modeling hypothesis might employ increasing intensities of acute noxious stimulation (e.g. electric shock). Facial expressiveness may provide a better index of subjective discomfort if it is not allowed to habituate over prolonged, continuous exposure to a noxious stimulus. Craig and his colleagues (e.g. Craig and Coren, 1975; Craig and Prkachin, 1978) have shown that social modeling can influence subjects' reports of pain in response to electric shocks of increasing intensity. If facial expressiveness increases in direct proportion to acute noxious stimulation of increasing severity, one could conceivably test the hypothesis that modeling affects more than just reports of pain.

Some methodological issues in the present study also require further clarification. For example, it is not clear to what extent facial activity during the cold pressor test was affected by the rating task. This issue could be resolved by comparing facial expressions among subjects required to rate their discomfort during the cold pressor test with those of subjects undergoing cold pressor exposure in the absence of the rating requirement. Another important question concerned the influence of experimenter demand characteristics on subjects' self-reports during the cold pressor test. To resolve this issue, it might be useful to eliminate such demand characteristics (e.g. by not telling subjects that the pain will increase with exposure time; by arranging the affective descriptors in a random order on the self-report panel) and observe whether discomfort ratings still follow a strictly ascending course. A final unresolved issue is whether the opportunity to observe a facially expressive or inexpressive model would alter subjects' own facial expressions of pain. Clearly, a more direct manipulation than that used in the present study is required - e.g. face-to-face live modeling; having subjects view a videotape of a facially expressive or stoical model prior to or during their exposure to the cold pressor test.

However, the most important mandate for future research is the study of individual differences in facial expressions of pain. Research is required to establish the range of individual variability and the personal and situational variables moderating these differences.

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Appendix A

"Unpleasantness" Descriptors* Comprising Self-Report Scale

Position on Ascending Self Report Scale	Descriptor	Relative Magnitude
1	Slightly unpleasant	2.8
2	Slightly annoying	3.5
3	Unpleasant	5.6
4	Annoying	5.7
5	Slightly distressing	6.2
6	Very unpleasant	10.7
7	Distressing	11.4
8	Very annoying	12.1
9	Slightly intolerable	13.6
10	Very distressing	18.3
11	Intolerable	32.3
12	Very intolerable	44.8

* Gracely, McGrath, and Dubner (1979)

Appendix B

Experimental Participation Consent Form

Name of Subject:____.

I hereby consent to participate in the study as described to me at this time by ________________________ (Experimenter's name).

I have been informed that the study will be videotaped and I give my consent with the understanding that the recording will be utilized for the purpose of further research only and not released without my written permission.

I understand that the risks to me as a subject in this study are minimal. To my knowledge there are no medical reasons which would prohibit my participation.

I further acknowledge that I have been advised that I can withdraw from participation in this study at any time without prejudice.

Signature:____________________________.

Date:____________________________.

Appendix C

Post-test Questionnaire

Name:______________________________.

Questionnaire

We'd like you to fill out this questionnaire based on your participation in this experiment. Please circle the number which best describes your opinion or fill in the blanks where appropriate.

1. How difficult was it for you to rate your discomfort?

very easy — very difficult

1 2 3 4 5 6 7

2. How painful was the cold water stimulus at its most intense period?

not painful at all — extremely painful

1 2 3 4 5 6 7

3. To what extent were you aware that you were being videotaped during the experiment?

not aware at all — very aware

1 2 3 4 5 6 7

4. To what extent did your awareness of the videotaping procedure affect your behavior during the experiment?

not at all — considerably

1 2 3 4 5 6 7

5. In your estimation, how long was your hand immersed in the cold water bath?

____________minutes ___________seconds

6. To what extent was your partner more or less tolerant of the cold water than you?

less tolerant — more tolerant

1 2 3 4 5 6 7

Appendix C (cont'd)

7. To what extent were your ratings of discomfort influenced by those of your partner?

not at all						considerably
1	2	3	4	5	6	7

8. To what extent do you think your partner's ratings were influenced by your responses?

not at all						considerably
1	2	3	4	5	6	7

9. How much opportunity did you have to observe your partner's facial expressions during the experiment?

none at all						considerable
1	2	3	4	5	6	7

10. Would you say your partner's face expressed more or less pain during the experiment than your own?

less pain						more pain
1	2	3	4	5	6	7

Appendix D

Debriefing Instructions

Now that the experiment is finished, I would like to describe to you in more detail the purpose of this study. As I mentioned before, you were being videotaped during the session. The videotapes we collect are in fact a main focus of our investigation. We are examining facial expressions of pain in people exposed either to a tolerant model, an intolerant model, or an inactive companion. In other words, your partner in this experiment was hired to enact one of these three roles. In the tolerant modeling condition, the model consistently provides lower ratings of discomfort than the subject and adopts a neutral facial expression. In the intolerant modeling condition, the model consistently provides higher ratings of discomfort than the subject and adopts a "pained" facial expression. In the other condition, the model does not participate in the experiment but is simply present in the room with the subject.

(AT THIS POINT THE EXPERIMENTER TOLD THE SUBJECT WHICH MODELING CONDITION SHE WAS EXPOSED TO AND EXPLAINED THE MODEL'S ROLE IN MORE DETAIL).

We will be coding the videotapes obtained in the different modeling conditions and comparing them to see whether this manipulation affects subjects' facial expressions of pain. We will also be looking at the effects of modeling on subjects' self-reports of discomfort recorded during exposure to the cold water. It was necessary to wait until after the session to inform you about our interest in your facial behavior so as not to make you self-conscious about it during the experiment.

Appendix D cont'd

I would also like to tell you that the electrodes attached to your arm were there simply to ensure that you kept still while being videotaped - we were not actually concerned with physiological responses in this study.

Do you have any questions about the procedure or purpose of this experiment?

I would like to thank you for your cooperation and ask you to refrain from discussing this experiment with your fellow students since some of them may be participating at a later date.

Appendix E

Confederate Training Procedure

Rating Procedure (Experimental groups only)

Each model received a copy of the following instructions, studied them, and then went over the procedure step by step with the experimenter. The experimenter provided explanations, examples, and feedback until each model was able to follow the rating scheme for each condition consistently and with few errors.

Tolerant modeling condition.

Rule 1. Model starts at lowest rating on panel. When subject gets two or more above, model makes lowest rating once more, then selects next higher descriptor.

If subject's first rating is three or higher, model selects lowest rating on her first turn, then goes one higher on her second turn. She continues advancing one descriptor per turn until she is one behind the subject.

Rule 2. If model manages to "catch up" with subject (i.e. makes a rating one step below subject's last rating) and then subject moves ahead on her next turn, model will repeat her last rating before advancing.

If subject doesn't move after model has caught up, model will stay one descriptor behind until subject does move.

Appendix E cont'd

Rule 3. If subject advances before model can approach within one descriptor, model will continue to move toward subject's level at a rate of one descriptor per turn.

Rule 4. Model will advance to subject's rating level if model has made eight consecutive ratings at a level immediately below that occupied by subject.

Rule 5. When subject terminates cold pressor exposure, model will move to the top of the scale at a rate of two descriptors per turn (unless she's already there), select the highest rating twice, and then withdraw.

Example:

Subject
2 3 4 4 5 6 6 8 8 9 10 (withdraw)
1 1 2 3 3 4 5 5 6 7 8 10 12 12 (withdraw)
Model

Intolerant modeling condition.

Rule 1. Model matches subject's first rating, and then advances one descriptor on the next turn (providing subject has not moved ahead).

If subject advances on her second rating, model will move one descriptor ahead of subject on her second rating (as long as jump is not more than three descriptors).

Rule 2. When subject advances to match model's rating, model will stay at same level for her next turn and then move to next higher descriptor (providing subject has not moved ahead again).

If subject matches model (and thus model repeats her last rating) and then subject moves ahead, model will move ahead of subject by one on her next turn (as long as jump doesn't exceed three descriptors).

Appendix E cont'd

Rule 3. Anytime subject jumps ahead of model, model will respond by moving ahead of the subject by one on her next turn (provided the jump doesn't exceed three descriptors).

If subject moves ahead of model, and model cannot immediately resume the lead without advancing by more than three descriptors, model will continue advancing on successive turns by jumps of at most three until she is again ahead by one descriptor.

Rule 4. When model reaches highest rating on the panel, she selects this rating twice, and then withdraws. If subject reaches the top first, model will advance to this position as fast as possible (maximum three descriptors per rating), remain there for two ratings, and then withdraw.

Example:

Subject	2	2	4	4	5	5	8	8	8	9	10	10	12	12 . . .
Model	2	3	5	5	5	6	9	9	9	9	11	11	12	12(withdraw)

Facial Expressions (Visual condition only)

Each model received a brief introduction to the Facial Action Coding System (FACS; Ekman and Friesen, 1978b), along with a description of the requirements for a neutral face and for a "pained" face (AU's 4, 10, and 25). Then the confederates were taught to assume the appropriate facial expression for each experimental condition, and maintain it for an extended period of time. The instructional procedure involved didactic, participant modeling, and shaping components.

Appendix E cont'd

Introduction to FACS.

The Facial Action Coding System (Ekman and Friesen, 1978b) is based on the analysis of the anatomical basis of facial movement - the examination of how each muscle of the face acts to create a visible appearance change. Although designed primarily to measure facial movement relevant to the display of emotion, FACS itself attaches no meaning to facial behavior. It is an objective scoring system and, as such, it can be used to study facial movement unrelated to emotion. FACS is a comprehensive scoring system which codes all visually distinguishable movements of the face.

Discrete facial movements are called Action Units (AU's). There are 44 single AU's (along with 20 more "action descriptors" - movements of the head, eyes, etc.); these can combine to form almost an infinite variety of different facial expressions. Facial movements are called action units and not muscle units because an appearance change may involve the actions of more than one muscle and because a muscle or group of muscles may be involved in more than one action unit. The numbers attached to the AU's are arbitrary and are used only as standard labels for the AU's.

It is important to remember that FACS does not attach emotional meaning to facial behaviors - any meaning is contingent upon the experimental situation in which FACS is used. In the present study, we have hypothesized on the basis of the available research literature that certain AU's will participate in the expression of pain/discomfort. By examining videotapes of subjects experiencing cold pressor pain, we will be able to determine whether any or all of these AU's are significantly present.

Tolerant modeling and control conditions.

Steps: a) Model instructed as to FACS requirements for a neutral expression: A neutral expression is one in which there are no detectable

Appendix E cont'd

AU's or facial movements evident. There is no tension in the face; it is completely relaxed. The mouth remains closed, the jaw is in a comfortable, "normal" position, and the eyes are open.

b) Experimenter modeled a neutral expression live, and provided examples of facial movements that create a non-neutral expression.

c) Model viewed a videotape of experimenter maintaining a neutral expression over a period of minutes, followed by a tape of experimenter demonstrating a "slightly" non-neutral face (i.e. exhibiting minute, scorable AU's). The fact that "neutral" means <u>no scorable facial behavior</u> was emphasized.

d) Model was asked to practice assuming a neutral face live, with the experimenter providing corrective feedback.

e) Model was asked to practice maintaining a neutral face for a full six minutes using a mirror as an aid. These sessions were videotaped, and played back to the subject along with verbal corrective feedback.

f) The previous step was repeated without the mirror as an aid.

g) In preparation for the tolerant (visual) modeling condition, the model was asked to maintain a neutral expression while practicing the "tolerant" rating scheme with the experimenter playing the role of the subject. These sessions were videotaped to provide feedback to the model.

h) In vivo practice with "real" subjects during pilot sessions for the experiment. Model received immediate videotaped feedback after each pilot session.

Appendix E cont'd

Intolerant modeling condition.

Steps:

a) Experimenter discussed with model the appearance changes involved in AU 4 (cf. Ekman & Friesen, 1978b). Emphasized the importance of making this change independent of other facial movements.

b) Experimenter modeled AU 4 live, pointing out the salient appearance changes. Also, noted how other subtle actions can contaminate the action of AU 4 alone.

c) Model viewed a videotape of experimenter maintaining first a neutral face, then performing AU 4 and maintaining it for approximately two minutes. Subsequent to this, the videotape showed AU 4 contaminated by other AU's (e.g. AU 7, AU 9).

d) Model practiced assuming AU 4 using a mirror as an aid, with the experimenter providing corrective feedback.

e) Model practiced performing AU 4 without the mirror; again, the experimenter offered feedback.

f) Steps a) through e) above were repeated for the AU combination 10 + 25.

g) Steps a) through e) were repeated for the AU combination 4 + 10 + 25.

Experimenter suggested that model follow a standard sequence for assuming this expression: AU 4 first, followed by AU's 10 and 25 in combination.

Appendix E cont'd

h) Model was asked to practice maintaining AU 4 + 10 + 25 for a full six minutes using a mirror as an aid. These sessions were videotaped to provide visual corrective feedback.

i) The previous steps was repeated sans mirror.

j) In preparation for the intolerant (visual) modeling condition, the model maintained the above expression while practicing the "intolerant" rating scheme with the experimenter acting as subject. These sessions were videotaped to provide feedback to the model.

k) In vivo practice with "real" subjects during pilot sessions for the study. Model received immediate videotaped feedback after each pilot session.

Appendix F

Scoring Units for the Facial Action Coding System (Ekman & Friesen, 1978b)

Upper Face

AU	Name
1	Inner Brow Raise
2	Outer Brow Raise
4	Brow Lower
5[a]	Upper Lid Raise
6	Cheek Raise
7	Lids Tight
41	Lids Droop
42	Slit
43	Closed
44	Squint
45	Blink
46	Wink

Lower Face

AU	Name
9	Nose Wrinkle
10[a]	Upper Lip Raise
11	Nasolabial Deepen
12[a]	Lip Corner Pull
13	Cheek Puff
14	Dimpler
15[a]	Lip Corner Depress
16	Lower Lip Depress
17	Chin Raise
18	Lip Pucker
20[a]	Lip Stretch
22	Lip Funnel
23	Lip Tight
24	Lip Press
25	Lips Part
26	Jaw Drop
27	Mouth Stretch
28	Lip Suck

Miscellaneous Actions

AU	Name	AU	Name
8	Lips Toward	33	Blow
19	Tongue Show	34	Puff
21	Neck Tighten	35	Cheek Suck
29	Jaw Thrust	36	Tongue Bulge
30	Jaw to Sideways	37	Lip Wipe
31	Jaw Clench	38	Nostril Dilate
32	Bite	39	Nostril Compress

Appendix F cont'd

Head Position

AD	Name
51	Turn Left[a]
52	Turn Right[a]
53	Head Up[a]
54	Head Down[a]
55	Tilt Left[a]
56	Tilt Right[a]
57	Forward
58	Back

Eye Position

AD	Name
61	Left[a]
62	Right[a]
63	Up
64	Down
65	Walleye
66	Crosseye

Other

AD	Name
0	Neutral
70	Brows Not Visible
71	Eyes Not Visible
72	Lower Face Not Visible
73	Entire Head/Face out of view
74	Unscorable

Note: AU = Action Unit; AD = Action Descriptor

[a]Can be scored for three levels of intensity.

Appendix G

Summary of Manipulation Check Data Analyses

Analysis 1[a] - Dependent measures: Initial discomfort rating; ease of rating; awareness of videotaping; effect of videotaping on behavior.

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Model	9.3715E - 01	4,2,66	0.520	8,126	0.8400
Cue	9.4257E - 01	4,1,66	0.960	4,63	0.4359
MXC	8.6016E - 01	4,2,66	1.232	8,126	0.2858

Analysis 2[b]- Dependent measures: Perception of model's tolerance; perception of model's influence on subject; perception of subject's influence on model.

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Model	4.6971E - 01	3,1,44	15.994	3,42	0.0000
Cue	9.6908E - 01	3,1,44	0.452	3,42	0.7172
MXC	9.0458E - 01	3,1,44	1.494	3,42	0.2299

Analysis 3[c]- Dependent measures: Subject's opportunity to see model's face; perception of model's facial expressiveness.

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Model	4.7598E - 01	2,1,16	8.257	2,15	0.0038

[a]All groups included in analysis.

[b]Only experimental groups included in analysis.

[c]Only tolerant and intolerant visual groups included in analysis.

Appendix H

Summary of Self-Report Data Analysis

Dependent measures: Magnitude of 5th rating; number of ratings below 7th descriptor; magnitude of final rating; number of ratings below 12th descriptor; tolerance (actual exposure time); post-test rating of pain severity; estimated exposure time.

Covariate: Magnitude of initial discomfort rating.

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Model	3.8892E - 01	7,2,65	5.087	14,118	0.0000
Cue	7.4785E - 01	7,1,65	2.866	7,59	0.0121
MXC	7.1462E - 01	7,2,65	1.542	14,118	0.1067

Appendix I

SUMMARY OF FACS DATA ANALYSES

Preliminary Analyses: Baseline (Segment 1) Versus Cold Pressor Exposure (Segments 2, 3, & 5).

Frequency Data

Hotellings T^21 - Dependent measures: Eight AU's consistent with Hjortsjo's(1969) descriptions of the pain expression (see Table IV).

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Segment (Baseline vs. Cold Pressor)	8.3765E - 01	8,1,215	5.039	8,208	0.0000
Subjects	3.2352E - 02	8,71,215	1.590	568,669	0.0000

Hotellings T^22 Dependent measures: All 15 AU's remaining after application of exclusion criteria and collapsing (see Table IV).

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Segment (Baseline vs. Cold Pressor)	7.7341E - 01	15,1,215	3.926	15,201	0.0000
Subjects	2.2799E - 03	15,71,215	1.457	65,17	0.0000

Duration Data

Hotellings T^21 - Dependent Measures: Eight AU's consistent with Hjortsjo's (1969) descriptions of the pain expression (see Table IV).

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Segment (Baseline vs. Cold Pressor)	9.2806E - 01	8,1,215	2.015	8,208	0.0462
Subjects	4.3018E - 02	8,71,215	1.430	568,669	0.0000

Appendix I cont'd

Hotellings $T^2$2 - Dependent measures: All 15 AU's remaining after application of exclusion criteria and collapsing (see Table IV).

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Segment (Baseline vs. Cold Pressor)	8.5614E - 01	15,1,215	2.252	15,201	0.0061
Subjects	2.7681E - 03	15,71,215	1.401	65,17	0.0000

Group Comparisons

Each of the following analyses was a 3 x 2 x 2 (Modeling x Cue x Segment) repeated measures MANOVA using as dependent measures the six AU categories found to occur more frequently during cold pressor exposure.

Analysis 1 - Videotape Segments 2 and 3

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Model	8.4279E - 01	6,2,66	0.908	12,122	0.5414
Cue	9.4756E - 01	6,1,66	0.563	6,61	0.7583
MXC	9.0151E - 01	6,2,66	0.541	12,122	0.8840
Segment	7.0096E - 01	6,1,66	4.337	6,61	0.0010
MXSeg	8.4026E - 01	6,2,66	0.924	12,122	0.5250
CXSeg	8.2712E - 01	6,1,66	2.125	6,61	0.0631
MXCXSeg	9.4706E - 01	6,2,66	0.280	12,122	0.9914
Subjects	2.1795E - 03	6,66,66	1.680	396,366	0.0000

Analysis 2 - Videotape Segments 2 and 4

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Model	8.4236E - 01	6,2,58	0.791	12,106	0.6585
Cue	9.3256E - 01	6,1,58	0.639	6,53	0.6986
MXC	9.1083E - 01	6,2,58	0.422	12,106	0.9517
Segment	7.6565E - 01	6,1,58	2.704	6,53	0.0230
MXSeg	7.2132E - 01	6,2,58	1.567	12,106	0.1123
CXSeg	8.5871E - 01	6,1,58	1.453	6,53	0.2122
MXCXSeg	8.3871E - 01	6,2,58	0.812	12,106	0.6375
Subjects	9.5506E - 04	6,58,58	2.047	348,318	0.0000

Appendix I cont'd

Analysis 3 - Videotape Segments 2 and 5

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Model	7.8164E - 01	6,2,66	1.333	12,122	0.2091
Cue	9.3066E - 01	6,1,66	0.758	6,61	0.6060
MXC	9.3439E - 01	6,2,66	0.351	12,122	0.9772
Segment	6.8398E - 01	6,1,66	4.697	6,61	0.0005
MXSeg	7.7656E - 01	6,2,66	1.370	12,122	0.1896
CXSeg	9.6714E - 01	6,1,66	0.346	6,61	0.9099
MXCXSeg	9.1916E - 01	6,2,66	0.438	12,122	0.9452
Subjects	2.6700E - 03	6,66,66	1.592	396,366	0.0000

Relationship Between Self-Report and Facial Expression

Each of the following was a stepwise multiple regression analysis examining the relationship between self-report magnitude and the frequency of "pain" AU's (i.e. the six AU's found in earlier analyses to be associated with cold pressor exposure). The data for each analysis were AU frequency scores from videotape segments 2 - 5.

Analysis 1 - All Groups

Variables in the Equation

Variable	Mult. R.	RSQ	RSQ Change	B	Beta	F test for Mult.R df	F
AU 6/7	0.1192	0.0142	0.0142	-2.936	-0.116	1,271	3.907*
AU 26/27	0.1414	0.0200	0.0058	2.207	-0.101	2,270	2.754
AU 12	0.1606	0.0258	0.0058	-1.353	-0.064	3,269	2.373
AU 10	0.1695	0.0287	0.0029	-2.129	-0.051	4,268	1.981
AU 25	0.1727	0.0298	0.0011	-0.782	-0.036	5,267	1.641

*$p < .05$

Variables not in the Equation

AU 43/45

Appendix I cont'd

Analysis 2 - Control Groups Only

Variables in the Equation

Variable	Mult. R.	RSQ	RSQ Change	B	Beta	F test for Mult. R df	F
AU 6/7	0.1374	0.0189	0.0189	-3.330	-0.147	1,89	1.713
AU 43/45	0.1659	0.0275	0.0086	0.565	0.084	2,88	1.244
AU 10	0.1762	0.0310	0.0035	-3.994	-0.079	3,87	0.929
AU 25	0.1858	0.0345	0.0035	1.259	0.064	4,86	0.768
AU 12	0.1923	0.0370	0.0025	-1.252	-0.056	5,85	0.652

Variables not in the Equation

AU 26/27

Segment 2 Data: Initial 10 Seconds of Cold Pressor Exposure

Baseline vs. Segment 2

Hotellings $T^2 1$ - Dependent measures: Frequency scores for eight AU's consistent with Hjortsjo's (1969) descriptions of the pain expression (see Table IX).

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Segment (Baseline vs. Segment 2)	5.8657E - 01	8,1,71	5.639	8,64	0.0000
Subjects	3.6461E - 03	8,71,71	0.954	568,526	0.7111

Hotellings $T^2 2$ - Dependent measures: Frequency scores for all 15 AU's remaining after application of exclusion criteria and collapsing (see Table IX).

Wilks Summary Table

Source	Wilks Lambda	df	Approx. F	df	Prob.
Segment (Baseline vs. Segment 2)	4.1150E - 01	15,1,71	5.482	15,57	0.0000
Subjects	1.6306E - 01	15,71,71	0.961	65,913	0.7330

Appendix I cont'd

Stepwise Multiple Regression Analysis

This analysis examined the relationship between magnitude of self-reported discomfort and AU frequency scores in videotape segment 2 (all groups included; $n = 72$).

Variables in the Equation

Variable	Mult. R.	RSQ	RSQ Change	B	Beta	F test for Mult.R df	F
AU 26/27	0.3144	0.0988	0.0988	1.258	0.333	1,70	7.677**
AU 6/7	0.3428	0.1175	0.0187	-0.777	-0.176	2,69	4.593*
AU 12	0.3631	0.1319	0.0144	0.617	0.136	3,68	3.442*
AU 5	0.3661	0.1341	0.0022	0.261	0.052	4,67	2.592*
AU 10	0.3676	0.1351	0.0011	0.233	0.033	5,66	2.062

**$p < .01$
*$p < .05$

Variables not in the Equation

AU 25