Ethnic differences in responses to multiple experimental pain stimuli

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Abstract

A growing body of literature suggests that the experience of clinical pain differs across ethnocultural groups. Additionally, some evidence indicates greater sensitivity to experimentally induced pain among African Americans; however, most studies have included only one pain modality. This study examined ethnic differences in responses to multiple experimental pain stimuli, including heat pain, cold pressor pain, and ischemic pain. Heat pain threshold and tolerance, ratings of repetitive suprathreshold heat, and ischemic and cold pressor pain threshold and tolerance were assessed in 120 (62 African American, 58 white) healthy young adults. Also, several psychological instruments were administered. No ethnic group differences emerged for threshold measures, but African Americans had lower tolerances for heat pain, cold pressor pain and ischemic pain compared to whites. Ratings of intensity and unpleasantness for suprathreshold heat stimuli were significantly higher among African Americans. African Americans reported greater use of passive pain coping strategies and higher levels of hypervigilance. Controlling for passive pain coping did not account for group differences in pain responses, while controlling for hypervigilance rendered group differences in heat pain tolerance and ischemic pain tolerance non-significant. These findings demonstrate differences in laboratory pain responses between African Americans and whites across multiple stimulus modalities, and effect sizes for these differences in pain tolerance were moderate to large for suprathreshold measures. Hypervigilance partly accounted for group differences. Additional research to determine the mechanisms underlying these effects is warranted.

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Keyword: Experimental pain

1. Introduction

Considerable evidence has demonstrated that the experience of clinical pain differs among ethnic groups (Edwards et al., 2001a,b; Green et al., 2003). For instance, African Americans report higher levels of pain in clinical conditions such as glaucoma (Sherwood et al., 1998), AIDS (Breitbart et al., 1996), migraine headache (Stewart et al., 1996), jaw pain (Widmalm et al., 1995), postoperative pain (Faucett et al., 1994; White et al., 1999), myofascial pain (Lawlis et al., 1984; Nelson et al., 1996), angina pectoris (Sheffield et al., 1999), joint pain (Rantanen et al., 1998), non-specific daily pain (Edwards and Fillingim, 1999), and arthritis (Anderson and Felson, 1997; Creamer et al., 1999), compared to whites. In contrast, others have reported no significant ethnic differences in clinical pain severity (Jordan, 1999; Todd et al., 1994). While research has suggested greater severity and prevalence of temporomandibular disorder in African Americans (Widmalm et al., 1995), recent research indicates higher frequency, earlier onset, and greater symptom severity among whites (Plesh et al., 2002). More recently, several investigators have noted ethnic differences in pain-related symptoms among African American patients with chronic non-cancer pain. Edwards et al. (2001a,b) found higher levels of pain and disability among African Americans relative to white patients seen in a multidisciplinary pain center. Other African
Americans studied in a chronic pain center reported higher levels of pain unpleasantness, emotional response to pain, and increased pain behaviors relative to whites (Green et al., 2003; Riley et al., 2002). Because ethnic differences in clinical pain responses can be influenced by factors such as disease severity and disparities in pain treatment, it is important to examine ethnic differences in pain perception among healthy individuals (Cleeland et al., 1997; McCracken et al., 2001; Stewart et al., 1996; Todd, 1996). Early laboratory studies, reviewed by Zatzick and Dimsdale (1990), suggested increased experimental pain sensitivity among African Americans as compared to whites. For instance, lower heat pain thresholds (HPThs) and tolerances were reported decades ago among African American subjects compared to whites by Chapman and Jones (1944). Similarly, cold pressor pain tolerances were lower in a combined group of African Americans and Hispanics in comparison to whites (Walsh et al., 1989).

Two more current studies have demonstrated greater sensitivity to heat pain among African Americans compared to whites, especially for measures of pain unpleasantness (Edwards and Fillingim, 1999; Sheffield et al., 2000). Additionally, recent research has indicated that African Americans described ischemic arm pain as more intense and unpleasant compared to whites when using standardized verbal descriptor scales, but not with individualized scales (Campbell et al., 2004). Thus, ethnic differences in responses to both clinical and experimental pain have been reported; however, most previous studies included only one form of experimental pain and varied considerably in their pain induction methods (Zatzick and Dimsdale, 1990). Therefore, the pattern of ethnic differences across different stimulus modalities has not previously been evaluated. Moreover, few investigators have examined the contribution of psychological factors to ethnic differences in pain perception, though multiple authors have noted the importance of evaluating the influence of these variables (Edwards et al., 2001a,b; Green et al., 2003; Rollman, 1998; Zatzick and Dimsdale, 1990). This study was designed to further elucidate the nature of ethnic differences in pain perception by investigating responses to multiple experimental pain modalities and assessing psychosocial variables that may contribute to group differences in pain sensitivity.

2. Methods

2.1. Participants

The total study sample consisted of 120 healthy young adults (62 African American, 58 white) recruited from a Southeastern University. Subjects received course credit for their participation in the study. Participant’s demographic information is presented in Table 1. The University of Alabama at Birmingham’s Institutional Review Board approved all study procedures.

All subjects participated in a single experimental session involving psychophysical testing. The data reported below represent information collected in two different experiments, and not all experiments included every pain task. Therefore, the number of subjects differs across pain tasks; however, the two ethnic groups were equally distributed across experiments. For all studies, verbal and written informed consent were obtained upon arrival; after which participants completed a health history questionnaire, which indicated that all were in good health and had no prior history of pain problems. Ethnicity was determined using self-report. Subjects who described themselves as either African American or non-Hispanic white were included in the analyses. Participants from other ethnic groups were not included in the analysis. This included 11 Asians, one Hispanic, one Native American, and four who endorsed the ‘other’ ethnic category. Next, subjects completed several psychological measures (see below).

After the questionnaires, the laboratory pain induction procedures were administered. In one experiment three pain procedures were conducted: thermal pain, ischemic pain, and cold pressor pain, and in the other experiment each of these except for cold pressor pain was completed. The thermal procedure was conducted first, followed by ischemic and cold pressor procedures (when applicable), and also administered in counterbalanced order. A 15-min rest period was observed between pain induction procedures.

2.2. Psychophysical measures

2.2.1. Thermal procedures

2.2.1.1. Threshold/tolerance. Contact heat stimuli were delivered using a computer-controlled Medoc Thermal Sensory Analyzer (TSA-2001, Ramat Yishai, Israel), a peltier-element-based stimulator with a 30 × 30 mm surface area. HPTh and heat pain tolerance (HPTo) were assessed on the left ventral forearm using an ascending method of limits. The temperature increased from a baseline of 32 °C with a 0.5 °C/s rate of rise, until the subject responded by pressing a button. Between trials the positioning of the thermode was moved up the arm slightly to avoid overlapping the testing sites and a 30-s inter-stimulus interval was maintained. The cutoff temperature (to avoid tissue damage) for all trials was 52 °C.

HPTh was determined first. Subjects were instructed to press a button on a hand held device when the thermode first produced a painful sensation. Each time the button was pressed, the temperature of the thermode was recorded. Four trials were conducted in order to obtain consistent results; the HPTh was determined as the average of these trials.

HPTo was then determined by instructing the subjects to press a button when the pain from the thermode became intolerable.

<table>
<thead>
<tr>
<th>Variable</th>
<th>African Americans</th>
<th>Whites (n = 58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (SD)</td>
<td>20.1 (2.6)</td>
<td>22.1 (5.8)</td>
</tr>
<tr>
<td>Sex (% female)</td>
<td>67.6</td>
<td>47.1</td>
</tr>
</tbody>
</table>

Table 1. Demographic Variables for African Americans and Whites

The cutoff temperature (to avoid tissue damage) for all trials was 52 °C.
The temperature of the thermode at the time the button was pressed was maintained during the trials. Four trials were conducted and HPTo was determined by averaging these trials.

2.2.1.2. Temporal summation. After a 5-min rest, the thermode described above was placed on the left dorsal forearm. A series of brief, repetitive, noxious thermal stimuli were administered twice in ascending order. The two inter-trial intensities were 38 and 41 °C, and the target temperatures were 49 and 52 °C, respectively. The target temperature was delivered for a 1.5-s duration, with a 3-s inter-pulse interval at the inter-trial intensity. Subjects provided either intensity or unpleasantness ratings of each stimulus using 0–20 box scales (Coghill and Gracely, 1996). Both series of stimuli were delivered twice, once for intensity ratings, and once for unpleasantness, in counterbalanced order. Subjects were instructed regarding the distinction between intensity and unpleasantness using a standardized script (Price et al., 1983). The trial was terminated if the subject said, ‘stop’ at any point or if they provided a rating of 20. Numerical ratings of each pulse were recorded.

2.2.2. Ischemic pain procedure

Ischemic pain was induced using a modified submaximal effort tourniquet procedure (Moore et al., 1979). The left arm was exsanguinated by elevating it above heart level for 30 s. The arm was then occluded using a 10 cm wide straight segmental blood pressure cuff (model SC-10) inflated to 240 mmHg using a Hokanson cuff inflator and air source (Bellevue, WA). Subjects performed 20-handgrip exercises of 2-s duration at 4-s intervals at the Hokanson cuff inflator and air source (Bellevue, WA). Subjects were instructed to keep his/her hand in the water for as long as possible, however if the pain became intolerable, participants were told that they could remove their hand at any time. Cold-pressor pain threshold was determined to be the time when the participant said, pain and tolerance was recorded when the hand was withdrawn from the water. Subjects were prompted to rate the unpleasantness and intensity of their lower arm and hand pain using the 0–20 box scales. The test was terminated when the subjects indicated they wanted to stop by saying, stop, when they reached 20 on either the intensity or unpleasantness scales, or when they reached an uninformined time limit of 15-min.

2.2.3. Cold pressor pain

Cold pressor pain was assessed by having the subjects immerse their left hand up to the wrist in 5 °C water. The water temperature was maintained (±0.1 °C) by a refrigeration unit (Neslab, Portsmouth, NH), and was constantly circulated to prevent local warming around the submerged hand. The subject was instructed to keep his/her hand in the water for as long as possible, however if the pain became intolerable, participants were told that they could remove their hand at any time. Cold-pressor pain threshold was determined to be the time when the participant said, pain and tolerance was recorded when the hand was withdrawn from the water. Subjects were prompted to rate the unpleasantness and intensity of the cold-pressor pain using the 0–20 box scales at 30-s intervals. Subjects continued until they reported intolerable pain or until a 5-min uninformined time limit was reached.

2.3. Psychological measures

In order to determine the contribution of psychosocial factors to group differences in experimental pain responses, all subjects completed the following psychological questionnaires.

The Coping Strategies Questionnaire (CSQ) (Rosenstiel and Keefe, 1983) consists of 44 items relating to how individuals cope with pain. It yields seven subscales based on the pain coping strategies that individuals report using: diverting attention, catastrophizing, praying and hoping, ignoring pain sensations, reinterpreting pain sensations, increasing behavioral activity, and coping self-statements. It has been widely used with various pain populations (Keefe et al., 1987; Parker et al., 1989) as well as with healthy young adults (Lefebvre et al., 1995). Previous factor analysis of CSQ subscales in clinical samples has revealed two higher-order factors, referred to as active and passive coping (Keefe et al., 1987), and these factors have been validated by other investigators (Snow-Turk et al., 1996). This factor structure has recently been replicated in a large sample of healthy, young African Americans and whites (Hastie et al., 2004). Therefore, we used the active coping and passive coping scales in our analyses.

The Kohn Reactivity Scale (KRS) consists of 24 items that assess an individual’s level of reactivity or central nervous system arousability. It has been recently used as a measure of the construct of hypervigilance (McDermid et al., 1996). This measure has been shown to correlate negatively with pain tolerance (Dubreuil and Kohn, 1986) and has been reported to have adequate internal consistency, ranging from alpha of 0.73–0.83 (Kohn, 1985).

The Pennebaker Inventory of Limbic Languishness (PILL) assesses the frequency of occurrence of 54 common physical symptoms and sensations and appears related to the construct of somatization or to the general tendency to endorse physical symptoms. It has been reported to have high internal consistency (alpha = 0.88) and adequate test-retest reliability (0.70 over 2 months) (Pennebaker, 1982). Recently it has been used as a measure of hypervigilance in fibromyalgia patients. These patients demonstrated lower pressure pain thresholds and tolerances and higher scores on the PILL compared to arthritis patients and pain-free controls (McDermid et al., 1996).

The Profile of Mood States- Bi-Polar (POMS-Bi) consists of 72 mood-related items, and subjects indicate the extent to which each item describes their current mood. This questionnaire assesses both positive and negative affective dimensions. The POMS has been well validated with other mood measures and is sensitive to subtle differences in affective state (Lorr and McNair, 1988). Though the POMS yields a variety of subscale scores, only the global indices of positive affect and negative affect were utilized in the present study.

3. Results

A total of 120 participants were studied, including 62 African Americans (41 female, with a mean age of 20.1 ± 2.6 years) and 58 whites (24 female, having a mean age of 22.1 ± 5.8 years). Age and sex differed between ethnic groups (P < 0.05); therefore, they were used as covariates in subsequent analyses. Analyses of covariance (ANCOVAs) revealed no significant differences in measures of HPTh, ischemic pain threshold, or cold pressor threshold. However, significant group differences emerged for HPTo, ischemic pain tolerance (IPTo), and cold pressor tolerance (CPTo) (P < 0.05), with African Americans displaying lower tolerances than whites. Significant differences also appeared for ratings of intensity and unpleasantness during the temporal
summation procedure at both 49 and 52 °C (P ≤ 0.005), with African Americans reporting greater pain compared to whites. Data for each of the experimental pain tasks are presented in Table 2. In addition, effect sizes and F-values for group differences on each pain measure are indicated. Fig. 1 depicts these data graphically, after standardizing the variables such that each pain measure had a mean of 50 and a standard deviation of 10.

ANCOVAs, controlling for sex and age, were also conducted in order to examine potential ethnic differences in psychological variables. These analyses revealed no group difference on the POMS, the PILL, or the Active Coping subscale of the CSQ. However, significant group differences emerged on the Passive Coping subscale of the CSQ (P = 0.0001) and the KRS scale (P = 0.003), with African Americans scoring higher than whites (see Table 3). In order to determine whether these psychological variables contributed to ethnic group differences in pain responses, ANCOVAs were performed. Group differences remained significant for all variables after adjusting for the Passive Coping subscale. However, controlling for KRS scores, both HPTo and IPTo became non-significant, while all other measures remain unchanged. Kohn Scores accounted for 20.2% of variance in HPTo, and decreased the variance accounted for by ethnicity from 5.2 to 2.7%. Kohn Scores accounted for 6.4% of the variance in IPTo and decreased the variance accounted for by ethnicity from 3.6 to 1.5%. Thus, KRS scores may have contributed to the group differences in HPTo and IPTo.

4. Discussion

The findings of this study provide evidence of ethnic differences in laboratory pain responses across multiple stimulus modalities. While African Americans did not differ from whites on threshold measures of heat pain, ischemic pain, and cold pressor pain, they exhibited significantly lower tolerances for each of the stimulus modalities. Group differences also emerged for ratings of the intensity and unpleasantness of pain at 49 and 52 °C. These findings suggest that African Americans may have different pain perceptions and responses compared to whites, which may be influenced by psychological factors such as coping strategies and stress levels. Further research is needed to investigate the underlying mechanisms and to explore potential interventions to address these ethnic disparities in pain.
Differences in pain sensitivity across ethnic groups are
considered important, as these procedures have been found to be
among the most clinically relevant experimental pain induction tasks (Edwards et al., 2001a,b; Petersen-Felix and Arendt-Nielsen, 2002).

Pain tolerance and suprathreshold ratings of pain unpleasantness may primarily reflect the affective-motivational dimension of pain, while pain threshold and suprathreshold ratings of pain intensity may be more strongly associated with sensory-discriminative aspects of the experience (Price, 1994). It has been theorized that ethnic differences in pain responses may be most apparent for the affective-motivational dimension of pain (Edwards and Fillingim, 1999; Riley et al., 2002; Sheffield et al., 2000). However, in the present study African Americans reported suprathreshold heat pulses to be more intense and unpleasant at both 49 and 52° when compared to whites. These findings suggest group differences in the sensory-discriminative aspects as well as the affective-motivational dimensions of pain perception. Taken together, these results are generally consistent with previous findings of ethnic differences in experimental pain (Chapman and Jones, 1944; Edwards and Fillingim, 1999; Sheffield et al., 2000; Walsh et al., 1989; Woodrow et al., 1972; Zatzick and Dimsdale, 1990) and chronic pain (Lawlis et al., 1984; Nelson et al., 1996).

Differences in pain sensitivity across ethnic groups are often attributed to ‘psychological factors’ such as anxiety, depression, and hypervigilance (Edwards and Fillingim, 1999; Edwards et al., 2001a,b; Green et al., 2003; Jordan et al., 1998; Rollman, 1998; Zatzick and Dimsdale, 1990). In the current study, no differences were observed in mood measures or in somatic complaints between groups. African Americans did; however, score higher on a measure of hypervigilance, the KRS, than whites; and this psychological factor was correlated with pain perception. Statistically controlling for KRS scores rendered group differences in HPTo and IPTo non-significant, while CPTo and heat pain ratings remained significantly different. This measure previously has been shown to negatively correlate with pain tolerance (Dubreuil and Kohn, 1986). One possible explanation for the change in significance of HPTo and IPTo could be that KRS data were missing for several subjects (five African Americans, and four whites); therefore, introducing this variable into the model reduced the power of the analysis. Although the mechanisms underlying this effect are unclear, heightened attention to painful stimuli may contribute to ethnic differences in pain responding.

Coping styles and strategies may also moderate the relationship between ethnicity and pain; and have been found to vary by culture (Jordan et al., 1998; Moore and Brodsgaard, 1999). Catastrophizing, an aspect of passive coping, has been associated with pain responses in both experimental (Sullivan and Neish, 1998; Sullivan et al., 1995, 1997) and clinical populations (Keefe et al., 1989; Tan et al., 2001). Catastrophizing is theorized to increase the attentional focus and/or increase emotional reactivity to pain, thereby amplifying its experience (Sullivan et al., 2001). Although African American participants reported greater use of passive pain coping strategies, including catastrophizing, this factor did not account for differences in pain responses between groups. However, it is important to note that the coping measure used in this study queried subjects as to their typical method of pain coping, and it is possible that subjects used different strategies to cope specifically with the experimental pain stimuli. Moreover, psychological factors not assessed in the present study could have influenced the current findings. For example, sociocultural or environmental influences may play a role in a person’s perception and response to pain and those factors were not directly assessed in this study. Given the consistency of ethnic differences in pain perception across stimulus modalities, these findings demonstrate the need for future research to address psychological variables and factors effecting pain coping and pain responses.

There are several limitations of the present study that should be noted when interpreting the results. First, all of the tasks were acute, controlled painful experiences. Given
the artificial nature of the experimental procedures, the outcomes may have limited practical utility. However, several studies have shown the relevance of using experimental pain induction procedures in order to predict clinical pain (Clauw et al., 1999; Edwards et al., 2003a,b; Fillingim et al., 1996; Granot et al., 2003; Langemark et al., 1989). In addition, because all participants were healthy college students recruited from a homogenous urban university population, the degree to which these findings generalize to other populations, including older and more poorly educated samples, is unknown. Another limitation, the inequitable gender representation across ethnic groups, was originally controlled for using ANCOVAs. However, in addition to controlling these variables statistically, ANCOVAs examining ethnic group differences separately for women and men were conducted to ensure the validity of the original results. While this separate analysis is not reported here, the results indicated that the ethnic group differences of similar magnitude for both women and men; therefore, the proportionately greater number of females in the African American group cannot explain the findings. In addition, limited information regarding income and cultural background are available. Participants were asked to report their income; however, some individuals reported personal income, while others reported household income; therefore, these data were not interpretable. Due to the limited information obtained about the sociocultural background of the participants, the mechanisms underlying group differences cannot be determined. Another limitation is that these data were collected in two different protocols, and the original purpose was not to examine ethnic differences. This led to a relatively small sample size for the cold pressor procedure, and it may have increased error variance, which may have reduced our ability to detect group differences on some pain tasks. Another issue is that the considerable heterogeneity within the broader category of ‘African American’ and ‘white’ was not investigated in the present study. Differences in experimental pain responses among subgroups within larger Ethnic categories have been reported (Chapman and Jones, 1944; Sternbach and Tursky, 1965); however, others have reported no significant intra-ethnic differences in pain responding (Granot et al., 2003; Lipton and Marbach, 1984).

These limitations notwithstanding, these findings indicate relatively consistent ethnic differences in responses to multiple experimental pain modalities, and the effects are generally moderate in magnitude. Also, the largest ethnic differences emerged for suprathreshold pain measures. Some group differences in psychological measures, such as coping and hypervigilance, were observed; however, these variables did not fully account for the ethnic differences in pain responses. The current findings provide further evidence for the existence of ethnic differences in experimental pain perception, and additional research to elucidate the mechanisms and clinical relevance of these effects is warranted.

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References


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