ORIGINAL ARTICLE

Laboratory personnel gender and cold pressor apparatus affect subjective pain reports

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BACKGROUND: There is no standardized method for cold pressor pain tasks across experiments. Temperature, apparatus and aspects of experimenters vary widely among studies. It is well known that experimental pain tolerance is influenced by setting as well as the sex of the experimenter. It is not known whether other contextual factors influence experimental pain reporting.
OBJECTIVES: The present two-part experiment examines whether minimizing and standardizing interactions with laboratory personnel (eg, limiting interaction with participants to consenting and questions and not during the actual pain task) eliminates the influence of examiner characteristics on subjective pain reports and whether using different cold pain apparatus (cooler versus machine) influences reports.
METHODS: The present experiment manipulated the gender of the experimenter (male, female and transgender) and the type of cold pressor task (CPT) apparatus (ice cooler versus refrigerated bath circulator). Participants conducted the CPT at one of two pain levels (5°C or 16°C) without an experimenter present.
RESULTS: Men and women showed lower pain sensitivity when they were processed by biological male personnel than by biological female personnel before the CPT. Women who interacted with a transgendered researcher likewise reported higher pain sensitivity than women processed by biological male or female researchers. The type of CPT apparatus, despite operating at equivalent temperatures, also influenced subjective pain reports.
DISCUSSION: The findings show that even minimal interactions with laboratory personnel who differ in gender, and differences in laboratory materials impact the reliable measurement of pain.
CONCLUSION: More standardized protocols for measuring pain across varying research and clinical settings should be developed.

Key Words: *Experimental pain; Gender; Pain assessment; Psychology; Social determinants of*

Le sexe du personnel de laboratoire et le dispositif d'épreuve au froid influent sur les déclarations de douleur subjective

HISTORIQUE : Il n'y a pas de méthode normalisée pour effectuer des épreuves au froid dans les diverses expériences. La température, le dispositif et l'aspect des expérimentateurs varient énormément d'une étude à l'autre. Il est bien connu que la tolérance à la douleur pendant les expériences est influencée par le lieu et le sexe de l'expérimentateur, mais on ne sait pas si d'autres facteurs contextuels influent sur les déclarations de douleur pendant les expériences.
OBJECTIFS : La présente expérience en deux volets visait à examiner si, en réduisant et en normalisant les interactions du personnel de laboratoire (p. ex., limiter l'interaction avec les participants au sujet du consentement et des questions et l'enrayer pendant l'épreuve de douleur même), on éliminait l'influence des caractéristiques des examinateurs sur les déclarations de douleur subjective et si l'utilisation de divers dispositifs de douleur par le froid (glacière plutôt que machine) influait sur les déclarations.
MÉTHODOLOGIE : Pendant la présente expérience, on a manipulé le sexe de l'expérimentateur (homme, femme et transgenre) et le type d'appareil utilisé pour l'épreuve au froid (ÉAF; glacière ou circulateur thermostatique réfrigérant). Les participants ont effectué l'ÉAF à l'un des deux niveaux de douleur (5 °C ou 16 °C), hors de la présence d'un expérimentateur.
RÉSULTATS : Les hommes et les femmes présentaient une moins grande sensibilité à la douleur lorsque leur cas était traité par du personnel de sexe biologique masculin que par du personnel de sexe biologique féminin avant l'ÉAF. De même, les femmes qui avaient des interactions avec un chercheur transgenre déclaraient une plus grande sensibilité à la douleur que celles dont le cas était traité par des chercheurs de sexe biologique masculin ou féminin. Le type de dispositif d'ÉAF, même utilisé à des températures équivalentes, avait également une influence sur les déclarations de douleur subjective.
EXPOSÉ : Les résultats démontrent que même des interactions minimales avec le personnel de laboratoire qui ne sont pas du même sexe et les différences de matériel de laboratoire utilisé influent sur la fiabilité des mesures de douleur.
CONCLUSION : Il faudrait mettre au point des protocoles plus normalisés pour mesurer la douleur dans divers milieux de recherche et milieux cliniques.

Experimental pain tests provide valuable information for understanding individual differences in pain sensitivities and clinical pain experiences (1-3). The efficacy of these experiments is contingent on the reliability of the methods used and the ability to control contextual and methodological factors that can influence pain measurements. Basic contextual factors, such as the gender of experimenters and other individuals in the immediate social context have been shown to influence subjective pain reports (4-8). The type of equipment used, such as during a cold pressor task (CPT), greatly varies across experiments and may influence the reliability of pain threshold, intensity and tolerance measurements in research settings (9,10). In the present experiment, we examined whether minimizing and standardizing procedural interactions with laboratory personnel (eg, limiting interaction with participants to consenting and questions and not during the actual pain task) eliminated the influence of examiner characteristics on subjective pain reports (4-7). We also examined how differences in CPT equipment may affect pain reports.

Several studies show that interaction with experimenters that differ in basic categories (eg, gender, authority role) and even the passive presence of others in the immediate social context influence subjective and autonomic pain responses (6,11,12). For example, experiments have shown that individuals are more likely to demonstrate heightened exogenous pain sensitivity when they are in the presence of a female researcher or peer (4,6,13). One study found that the absolute number of female but not male strangers present during an ischemic pain task is linearly associated with hyperalgesia in women and in hypoalgesia in men (8). These findings have been explained from a social-signalling (evolutionary psychology) perspective that is based on the prediction that women evolved the behavioural heuristic (ie, reflexive tendency) to express higher levels of pain reaction behaviours (eg, hyperalgesia) and pain-empathizing behaviours than men in general as part of a broader expressive style characterized by the heightened demonstration of trustworthiness cues (8,14-19). This perspective purports that the tendency for individuals to implicitly perceive women as sources of solicitude, consolation and logistical assistance may have co-evolved with the behavioural heuristic for individuals, and especially women, to heighten the expression of pain percepts (eg, hyperalgesia) in the presence of fellow women and, hence, the types of social agents who are

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most likely to provide solicitous responses to someone in pain. The practical significance of this effect is that it is a methodological confound that is difficult to control in clinical and research settings in which pain reports are documented by laboratory personnel. What is not known is whether minimizing and standardizing procedural interactions with laboratory personnel such as the use of a protocol in which individuals conduct a discomfort task in solitude, without the physical presence of the personnel during the task, eliminates the influence of social contextual factors on subjective pain reports.

Interestingly, the type of apparatus that experimental pain researchers use varies widely across studies. For cold pressor testing, a variety of homemade cold water circulators and commercial machines have been described (9,10). To our knowledge, different types of equipment have not yet been compared to better understand the reliability of cold pain measurement. Another important aspect to consider is the noise level of the equipment used in a laboratory. This is relevant because the more technologically advanced equipment for inducing laboratory pain, such as automated bath circulators used in CPTs, tend to be noticeably louder than older equipment (eg, custom-designed ice coolers) used in the majority of previous cold pressor pain experiments (9,10). Clinical studies show that attention-demanding factors, such as the noise level of equipment in a patient's hospital room, can influence their health (20,21). These effects have been hypothesized to operate through the aversive effects of loud noises on sympathetic stress responses (eg, heightening blood pressure and heart rate [22-25]). Noise levels have also been shown to influence experimental pain reports somewhat differently in men and women (26). However, to our knowledge, no study has directly compared pain sensitivity using different types of CPT apparatus that are otherwise equivalent in their reservoir water temperature levels.

In the current experiment, we examined whether minimizing and standardizing experimenter-participant interactions before a CPT eradicates the influence of experimenter gender on CPT pain sensitivity. The present experiment uniquely created a CPT protocol that enabled participants to complete the discomfort task entirely on their own, without the physical presence of a researcher during the task itself. The experimenters included male, female and transgendered individuals, resulting in a unique data opportunity to examine gender-based social experiences on CPT pain. We also examined whether type of CPT apparatus influenced pain reports by comparing the use of a traditional, inexpensive CPT protocol (ie, use of a small ice cooler) with a more technologically advanced (eg, automated) protocol that used a mechanical refrigerated bath circulator to induce CPT pain. Secondary analyses examined the possibility of gender differences in these effects and, thus, how common methodological factors may influence experimental pain results in healthy men and women.

METHODS

Participants

The protocol was approved by the University of New Mexico's Institutional Review Board and two forms of written consent were obtained from all participants. The first consent form described the general experimental protocol, and the second described the CPT in more detail. Participants included a convenience sample of undergraduates. Participants who self-identified contraindication(s) to the CPT were excluded from the study. Contraindications included any illness related to a cardiovascular disorder (eg, high blood pressure, heart disease or dysrhythmia), history of fainting or seizures, history of frostbite, having an open cut, sore or bone fracture on the limb to be immersed in water, or a history of Reynaud's phenomenon (abnormal discolouration of the skin with exposure to heat and cold). The sample consisted of 352 adults (mean [± SD] age 19.8±2.1 years; range 18 to 30 years; 48% male; 40% Caucasian, 40% Hispanic and <6% black, Asian and Native Americans). Two different experimental conditions were used in the present study: cold pressor temperature condition (nonpainful, 16°C; or painful, 5°C); and CPT apparatus condition (cooler or mechanical circulator). Participants were randomly assigned to temperature condition and to CPT apparatus condition; 60% of participants (n=211) were in the painful conditions (5°C), 40% (n=139) were in the nonpainful conditions (16°C), 55% were in the cooler conditions (n=195), and 45% were in the mechanical device conditions (n=157). The sex ratio of participants was not statistically different across any of the experimental conditions (P>0.10).

Procedures

Participants interacted with and were assisted through the experimental protocol by one of 15 research assistants: seven self-identified male, seven self-identified female and one self-identified male-to-female transgender researcher. Gender of the researchers was operationalized as the outward expression or appearance of culturally defined masculinity and femininity. All of the male researchers had a masculine demeanor, all of the female researchers had a feminine demeanor, and the transgendered researcher had a predominantly female demeanor. Forty-six per cent of participants (n=162) interacted with a female researcher, 49% (n=171) with a male researcher and 5% (n=19) with the transgendered researcher (eight of the researchers were European-American and seven of the researchers were Hispanic). The researchers followed a script for every phase of the experiment to minimize the possible influence of interpersonal factors (eg, duration of conversations) that were not directly associated with gender identity of the researcher. Following a scripted informed consent procedure, participants were measured for body proportions and vision acuity, which lasted for 3 min to 5 min (the measurements were not used in the current study). Participants were then escorted to an assessment room where they were left alone to complete a demographic questionnaire and to view a video that provided instructions for performing the CPT without a researcher present. The video provided directions for using the cold pressor apparatus and indicated various pain ratings; a female narrator's voice was used, and a confederate male participant and the cooler were depicted in the video. The survey and instructions video took approximately 30 min to complete.

Once participants had viewed the instruction video, they were led into the room with the cold pressor apparatus. The cold pressor room was fitted with a video monitor for viewing the participants from a remote location, a cold pressor apparatus and a laptop programmed with user-interfaced pain assessment software. The computer program was used to electronically measure participants' self-indicated pain intensity ratings at 30 s into the CPT, as well as the time latency for felt discomfort (discomfort threshold), felt pain (pain threshold), and point in the task when the participant chose to discontinue the task because they could no longer tolerate the pain (pain tolerance), described in detail below. Finally, the experimenter told the participant that they would be monitored via a video feed and that they could start the procedure at any time upon their choosing; the experimenter then left the room and closed the door behind himself/herself. The individual participant then performed the cold pressor task without an experimenter present. The experimenter observed the participant via live video feed from the next room to ensure adherence to the cold pressor procedure. This innovative method enabled researchers to collect CPT data without being physically present during the CPT. None of the CPT sessions used in the present analyses were interrupted prematurely for any reasons. The participants spent a total of 5 min to 7 min interacting with the laboratory personnel (eg, to take body measurements, escorting the participants to various laboratory rooms) before the CPT.

Questionnaires

A basic questionnaire created by the authors' laboratory included demographic characteristics such as sex, age, ethnicity and level of schooling.

CPT

Cold pressor apparatus: Participants were seated in a chair between the pressor apparatus (left side) and the laptop computer (right side) in a small room (2.0 m × 2.5 m). The traditional cooler apparatus consisted of a small, insulated ice box (approximately 30.5 cm × 19 cm × 27.5 cm); the cooler was purchased inexpensively from a large retail store. The cooler was fitted with a small, inexpensive water circulator (ie, fish tank

pump) and filled with ice water until it reached the desired temperature levels. In the nonpainful condition, the ice water was set to 16°C (noticeably below room temperature, but only slightly distressful under normative conditions), and in the painful condition, the water was set to 5°C (known to produce a range of pain tolerance levels with only minimal ceiling effects [9]). Small differences in water temperature (2°C) can have significant effects on pain sensitivity measures (27), and all the participants in the current study experienced water temperatures within 1°C of each other in the high pain and low pain conditions. A circulator was used to prevent the water warming around the participant's hand in both CPT apparatus, and precise thermometers were used to establish the reliability of the water temperatures across the CPT conditions.

The electromechanical CPT device was an Isotemp 6200R28 (Fisher Scientific, USA) refrigerated bath circulator with a reservoir that was comparably sized (approximately 28 cm × 16.5 cm × 22 cm) to the coolers used in the other apparatus condition. The machine circulates the water automatically and maintains a consistent water temperature within 0.1°C by dual heating and cooling actions. The device itself was physically larger (approximately 66 cm × 25 cm × 81 cm) than the cooler apparatus, had a chrome finish, and was noticeably louder than the water pump used with the cooler apparatus. The CPT apparatus were set in the same proximity so that the participant's limb naturally rested into the water from a relaxed seated posture.

Pressor procedures: The pain assessment program (on the laptop) displayed an initial screen with the general CPT instructions. The researcher verbally reiterated the instructions by describing that when participants choose to both begin and to end the task, they were to perform two simultaneous actions. To begin the task (and initiate the pain assessment program), participants were instructed to first indicate their baseline (pre-manipulation) pain severity along a standard visual analogue scale (ranging from 0 to 10, with 0 indicating no pain and 10 indicating the worst pain imaginable), while simultaneously submerging their left hand into the cold water to a marked line on the wrist (2.5 cm above the wrist joint). To end the task, participants were instructed to indicate this preference electronically by clicking on a corresponding icon on the computer screen while simultaneous lifting their hand out of the cold pressor apparatus. Participants were also instructed to immediately click on two additional icons that would be on the computer screen continuously and used to measure: when the participant first felt a 'discomfort sensation'; and 'when the discomfort sensation transitioned into a pain sensation' (based on the participant's subjective impression), respectively. Likewise, participants were instructed to indicate their felt pain intensity (from 0 to 10) on an audio prompt and illumination of a pain visual analogue scale that was programmed to take place at 30 s into the CPT.

Once the participants indicated their understanding of the instructions, they were fitted with a finger pulsometer to monitor their heart rate during the CPT. Last, the researcher reminded the participant that they would be recorded, and that they could begin the task whenever they desired. The researcher then left the cold pressor room and closed the door. The procedure was observed on a video monitor from a remote location, and the researcher returned to the experimental room to debrief the participant once they retracted their hand from the water or after the maximum duration of 5 min had occurred (the participants were not informed of this time limit). Following debriefing, participants were asked to rest for 5 min to ensure they no longer felt any physical discomfort from involvement in the study and that their heart rate had returned to normal.

Data analyses

The pain scores included the participant's discomfort threshold, pain threshold, pain tolerance (measured in seconds postsubmersion) and the pain intensity score. Higher intensity scores and lower threshold and tolerance scores were interpreted as indicating greater CPT pain sensitivity (reverse effect sizes of threshold and tolerance scores reflect greater pain sensitivity). ANOVAs were used to examine the separate effects of personnel's gender and CPT apparatus on the pain scores; independent-samples *t* tests were used to compare group differences, and effect sizes pertaining to group comparisons were estimated with Cohen's d (mean difference/mean standard deviation [28]). Secondary analyses were conducted to examine the impact of group assignment on the pain scores separately for men and women. The analyses pertaining to personnel's gender focused primarily on self-identified (biological) male or female researchers. However, given the uniqueness of the data pertaining to the transgendered researcher, group comparisons between these data and those pertaining to the other researchers were included in the secondary analyses.

RESULTS

Laboratory personnel's gender

To examine whether gender of the laboratory personnel during the pretest phase influenced CPT performance, an ANOVA was performed for each of the four pain scores (discomfort threshold, pain threshold, pain tolerance, pain intensity) using the entire sample (ie, combined apparatus groups), and with examiner gender, CPT temperature, and the examiner gender × temperature interaction terms as predictor variables (information from the transgendered researcher were not included in these analyses). Information from participants processed by the transgendered researcher was not included in these analyses due to the relatively small sample size. Significant main effect terms for personnel's gender emerged for pain intensity ($F[1,283]=6.74$; $P=0.010$) and a significant experimenter × temperature interaction term emerged for pain tolerance ($F[1,319]=8.95$; $P=0.003$); personnel gender was not a significant predictor of either of the threshold scores ($P>0.10$). The significant main effect was due to higher mean pain intensity scores for participants processed by a female researcher (3.56±2.06) than a male researcher (3.14±2.06, d=0.20).

Laboratory personnel's gender (male or female) showed a trend for group differences in discomfort threshold ($t[184]=1.77$; $P=0.062$), and significant differences in the pain intensity score ($t[155]=–2.09$; $P=0.038$ and the pain tolerance score ($t[172]=3.41$; $P<0.001$) when participants were tested in the painful condition only. These differences were due to slightly lower pain intensity and to moderately higher pain tolerance scores for participants processed by a male researcher (4.19±1.96 and 160.46±132.10, respectively, d=0.33) compared with participants processed by a female researcher (4.83±1.89 and 102.19±100.81, respectively, d=–0.50). In the nonpainful condition, laboratory personnel gender had no significant effect on any of the experimental outcomes.

Subject differences: Secondary analyses comparing the pain scores between the male and female participants in the painful condition showed significant group differences for pain threshold ($t[196]=2.05$; $P=0.042$), pain tolerance ($t[166]=3.57$; $P<0.001$) and pain intensity, ($t[164]=–2.48$; $P=0.014$). Mean pain scores for male and female participants processed by the biological male, biological female and the transgendered researchers in the painful condition are shown in Table 1. Among male participants, examination of the pain scores between participants processed by the biological male or biological female personnel in the painful condition showed a significant group difference for discomfort threshold ($t[78]=2.42$; $P=0.042$). Among female participants, a similar analysis revealed a group difference for pain tolerance ($t[66]=2.35$; $P=0.022$). These differences were due to higher discomfort threshold scores among men processed by a male researcher than by a female researcher (d=0.50). In contrast, and as shown in Figure 1, only women processed by a male researcher showed higher pain tolerance scores compared with women processed by a female researcher (d=0.48). Figure 1 also shows that, compared with participants processed by a male researcher, participants processed by the transgendered researcher showed much lower pain tolerance scores (d=–1.11) and, thus, these scores were more similar to participants processed by a biologically female researcher.

CPT apparatus

Next, CPT apparatus (cooler or mechanical device), CPT temperature, and the apparatus × temperature interaction term were compared as predictor variables for each of the pain scores using

TABLE 1
Pain scores for men and women in the painful condition* according to researcher gender

	Researcher gender		
	Male	Female	Transgendered
Men			
Discomfort threshold†	23.45±20.92‡	15.16±10.13‡	16.46±9.57‡
Pain threshold†	47.37±30.84‡	38.92±20.90‡	56.11±53.07‡
Pain tolerance†	178.59±139.25‡	135.53±119.22‡	164.27±157.07‡
Pain intensity (VAS score)	3.93±1.82‡	4.40±1.76‡	4.00±1.41‡
Women			
Discomfort threshold†	17.71±13.78‡	16.63±19.25‡	8.72±6.22‡
Pain threshold†	38.88±22.42‡	36.56±35.38‡	23.13±9.90‡
Pain tolerance†	137.47±120.17§	86.77±87.81‡	42.35±18.61‡
Pain intensity (VAS score)	4.51±2.12‡	5.04±1.93‡	4.67±1.53‡

*Data presented as mean ± SD. *Water temperature set at 5°C; †Seconds postsubmerson; ‡§Different symbols between groups indicate significant differences between the researcher gender conditions using a Bonferonni correction (P<0.017) for multiple comparisons. VAS Visual analogue scale*

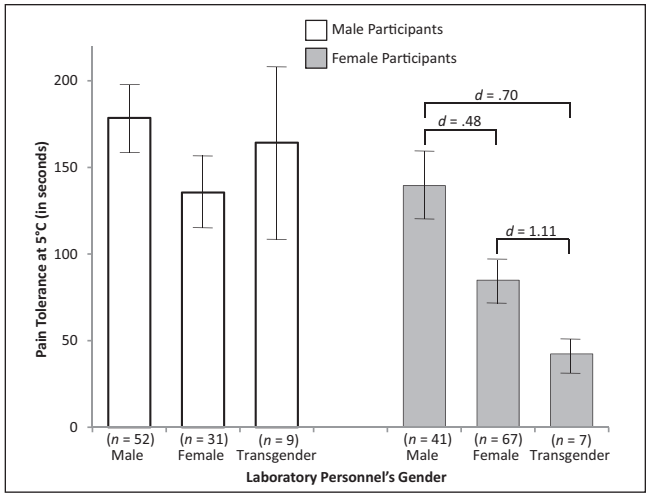

Figure 1) *Group differences in pain tolerance for men and women processed by a male, female or transgendered personnel member. Bars represent SEM*

TABLE 2
Pain scores for men and women in the nonpainful conditions* using two types of cold pressor task (CPT) equipment

	CPT apparatus	
	Ice cooler	Mechanical circulator
Men		
Discomfort threshold†	79.63±89.86‡	56.95±56.01‡
Pain threshold†	171.27±117.03‡	133.98±56.87‡
Pain tolerance†	305.96±75.81‡	303.83±81.01‡
Pain intensity (VAS score)	1.73±1.36‡	1.63±1.25‡
Women		
Discomfort threshold†	93.35±119.76‡	50.83±51.81‡
Pain threshold†	172.29±140.97‡	78.76±36.86§
Pain tolerance†	355.15±136.83‡	295.68±79.05§
Pain intensity (VAS score)	2.37±1.79‡	2.36±1.34‡

*Data presented as mean ± SD. *Water temperature set at 5°C; †Seconds postsubmerson; ‡§Different symbols between groups indicate significant differences between the researcher gender conditions using a Bonferonni correction (P<0.017) for multiple comparisons. VAS Visual analogue scale*

the entire sample (ie, combined personnel groups). These analyses showed significant apparatus × temperature interaction terms for discomfort threshold (F[1,314]=5.47; P=0.020) and pain threshold (F[1,284]=14.60; P<0.001). Follow-up analyses examining the effect of CPT apparatus separately for participants in the two temperature conditions showed group differences for participants in the nonpainful condition (16°C) only for discomfort threshold (*t*[106]=2.04; P=0.044) and for pain threshold (*t*[88]=3.72; P<0.001), but not in the painful condition (P>0.10). Participants in the mechanical apparatus condition showed lower discomfort (mean score 55.40±54.00) and pain thresholds (101.26±52.84) than participants in the cooler condition (85.48± 103.06 and 171.71±126.75, respectively), and the effect sizes ranged from modest to large (d=0.37, d=0.73).

Subject differences: Secondary analyses comparing the pain scores between the male and female participants in the nonpainful condition showed a significant group difference for pain intensity (*t*[132]=02.74; P=0.007. Independent samples *t* tests examining the effect of CPT apparatus on the pain scores separately for males and females in the nonpainful condition showed that, for females only, group differences emerged for pain threshold (*t*[32]=3.26; P=0.003) and pain tolerance (*t*[62]=2.15; P=0.036); none of the effects was significant for males (P>0.10). As shown in Table 2, only women who used the mechanical apparatus had lowered pain threshold scores (d=0.90) and lower pain tolerance scores (d=0.53) than women tested with the cooler condition.

DISCUSSION

The present study uniquely provides support that there are myriad situational and contextual factors that influence experimental pain sensitivity and that some basic methodological confounds may be challenging to control. Specifically, and similar to previous studies investigating the impact of audience effects on experimental pain tasks (6,8), we found that minimal procedural interactions with a biological female researcher before conducting the CPT was associated with higher pain sensitivity (lower discomfort threshold and pain tolerance and higher intensity) compared with interactions with male researchers. Interestingly, we found that interacting with the male-to-female transgendered researcher was associated with the lowest pain tolerance scores for female participants only and, thus, more similar to results obtained from the biological female personnel. We also showed that, despite inducing equivalent CPT temperature levels, the type of CPT apparatus and, thus, a tangential aspect of the experimental procedure, influenced subjective pain ratings. In general, use of the electromechanical refrigerated bath circulator produced higher pain sensitivity measurements (lower threshold and tolerance scores) than did the traditional ice cooler apparatus. Both of these effects (personnel and apparatus influences) were generally more apparent in female than in male participants. Thus, while previous research has found that social, contextual characteristics during an experimental pain task and emotionally charged social interactions before such a task can affect pain sensitivity (8,29), this is the first study to show that basic procedural interactions with laboratory personnel, circumscribing the actual pain task, and that tangential characteristics of the CPT equipment itself influenced subjective pain ratings. These findings support previous calls (9,10) for more standardized protocols for measuring pain reports across pain experiments and perhaps clinical settings.

The personnel-related findings can be interpreted in part from the broader, social-signalling, evolutionary psychology perspective, that the behavioural expression of pain sensations operate, in part, for signalling vulnerability to other individuals. Specifically, and in addition to facilitating learning (eg, operant conditioning [20,31]) and self-awareness (eg, to protect an injured body part), pain percepts are functional for signalling gestures (eg, pain reports) that demonstrate nonthreat and, ultimately, trustworthiness trait impressions, which individuals tend to heuristically direct toward intimate and reliable relationship partners such as family and close peers (15,17). Pain signalling of others is, in turn, contextually exploited by such individuals as an opportunity to selectively demonstrate reciprocal altruism (eg, expressed empathy, logistical provisioning) and, hence, trustworthiness cues back toward the individual experiencing pain (18,32,33). Thus, from this social-signalling perspective (17,34,35), pain percepts should be most intense during interactions with intimate affiliates and prototypical relationship partners who are most likely to demonstrate solicitude toward the individual experiencing pain (18,32).

Women may, therefore, express higher levels of vulnerability and altruistic gestures including pain suffering and pain empathizing behaviours than men, on average (8,17-19), as part of a broader social style that evolved for advertising trustworthiness cues for maintaining fewer, more intimate (ie, time-consuming and investing), and more exclusive relationships throughout human natural history (14-17,36). Men, in contrast, tend to form more fluid and less intimate peer relationships, which explains their heuristics for demonstrating capacity cues (eg, prowess, independence, selfishness) rather than trustworthiness cues, including lower levels of pain intensity and pain empathizing behaviours (8,17,18). Thus, from the perspective of this 'socio-relational' model (8,18,19), women were predicted to express higher levels of pain sensitivity as a result of more frequent and recent interactions with other women, and to express lower pain sensitivity from interactions with men.

These hypotheses have been supported using experimental protocols that examine pain percepts in the immediate presence of other individuals (both friends and strangers [8,13,19,37,38]). The current study extends this research by showing that even minimal, previous, procedural (scripted) interactions with female researchers also led to higher pain reports in women, even when the felt discomfort was experienced in solitude, without the physical presence of another person. Finally, we showed that interactions with a biological male with a self-described female gender identity resulted in subjective pain reports that were more similar to reports of women who interacted with a biological female versus a male personnel member. These latter findings may, therefore, suggest that the effect of researcher's gender on experimental pain reports may stem from interpersonal appraisal processing of explicit gender cues (eg, the transgendered researcher had a very feminine appearance and demeanor) rather than, or perhaps in addition to reactions to implicit biophysical sex markers (eg, pheromones). Still, this inference is only speculative given that the personnel's gender identity was not explicitly measured and due to the small number of participants that interacted with the transgendered researcher and the absence of more than one transgendered researcher.

The observed findings show that the types of interactions that individuals have with researchers and auxiliary laboratory staff influence the ability to reliably measure pain under otherwise controlled experimental conditions. This effect emerged despite the use of a protocol that was able to utilize minimal interpersonal interactions and was able to entirely eliminate the physical presence of an examiner during the actual pain task. These results, therefore, highlight the extraordinary difficulty of attempting to design an experimental pain measurement protocol that can avoid even minimal social interactions, entirely. Nearly all extant pain stimulus studies have relied on protocols with these potential confounds. Given the statistical magnitude of these effects, it is probable that clinical staff may also influence patient pain reports in health care settings. Only one study to date has examined the impact of the gender of healthcare examiners on patient pain reports (41), and although the sample size in this investigation was relatively small, the results were similar to the current findings. There is some preliminary support that patient treatment may also be associated with health provider's gender, with female physicians showing a tendency to prescribe higher doses of analgesics to underserved patient populations, such as ethnic minorities and other women, compared with male physicians (39,40). Nonetheless, the current study shows that commonly uncontrolled social factors influence experimental pain results, and that it will be a challenge for pain experimenters to be able to devise research designs that can better manage these heretofore unrecognized confounding sources of pain measurement error.

The other previously unrecognized source of measurement variability examined in the current study was the influence of laboratory setting details associated with using different types of CPT equipment. Unlike the personnel effects described above, the apparatus effects were only evident in females at relatively low discomfort levels and thus under conditions in which pain sensations were not expected to be as (attentionally) demanding. It is likely that the more formal style (chrome finish and digital LCD screen) and noticeably louder noise level of the refrigerated bath circulator may have resulted in modest fear or anxiety-induced hyperalgesic effects. This interpretation is consistent with the hypothesis that loud noises adversely affect health via sympathetic stress responses (eg, heightening blood pressure and heart rate [22-25]) and with other research showing sex differences in the impact of noise on experimental pain reports (26). The current study extended this and other previous research on methodological factors that influence CPT results (10) by showing that biological sex may moderate some effects of variable CPT equipment on experimental pain reports. Thus, while the use of more technologically advanced equipment is generally recommended for implementing experimental pain tasks (eg, for their increased reliability [9,10]), researchers should take caution when comparing the results of studies that use different types of equipment, despite being able to induce equivalent components of noxious stimuli intensity levels (eg, temperature, mechanical pressure).

In addition to the project's potentially innovative findings, discussion of limitations is warranted. General methodological limitations are that: we did not control for handedness, which has been shown to influence CPT measurements (42); reactions to CPT might not predict reactions to other pain sensations (experimentally and clinically); results from a convenience sample of college students may not generalize to different demographic groups; and gender differences may be influenced by cultural (eg, ethnic) norms, or 'display rules' regarding the expression of pain behaviours (43). It is also likely that initial floor effects confound experimental pain tasks in which felt pain quickly becomes unbearable. Another limitation is that, although we tried to control the potential influence of observer effects, it is still possible that individuals responded to the virtual presence of the (remote) experimenter in ways that confounded the ability to examine our proposed hypotheses. Likewise, although we were able to control one significant component of noxious stimuli intensity (temperature of cold bath reservoirs) there are numerous additional factors that can affect discomfort intensity levels, such as the rate and turbulence of water flow which affects heat flux (in this case, transfer of heat from the hand/arm to the cold water). Factors such as these can be difficult, although not impossible, to measure and to make equivalent across different types of apparatus (44). Finally, use of only a single instruction video (depicting the ice cooler, male confederate and a female narrator's voice) could have influenced the pain measurements via congruent/incongruent expectancies (exposure to novelty), perhaps increasing affective arousal, and not due to the specific characteristics of the CPT apparatus itself.

Collectively, the current findings extend previous research on gender differences in social situational factors that influence pain perception by showing that even minimal procedural interactions with other individuals before conducting an experimental pain task can influence subjective pain ratings. Protocols that seek to minimize these effects, such as standardizing the presence of a researcher during the discomfort tasks or using participants with the same gender, are associated with unintended empirical consequences and

conceptual limitations including the ability to understand important sex differences in pain perception. Immediate and complete solutions for controlling these seeming current sources of measurement error therefore remain elusive at the present time. Should the presently observed personnel-based influences be validated with clinical populations, they would hinder the ability to reliably measure patient pain functioning and pain management outcomes. However, given the ubiquity of social influences on human pain perception, it may behoove researchers, clinicians, and pain theorists to consider the pain experience as an inherently social phenomena, and to take social contextual influences into more consideration when interpreting pain reports, rather than merely trying to eliminate these otherwise methodological confounds altogether. Nonetheless, a better understanding of how social experiences modulate pain perception in vivo and in vitro will remain important for designing more standardized protocols for reliably measuring and interpreting subjective pain reports.

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