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Subjects served as their own control when tooth pulp shock was delivered in laboratory and clinical situations. Significantly heightened pain was observed in the clinical dental setting. The dental setting proved more anxiety-provoking and associated with reduced tolerance for pain, suggesting that cognitive contexts of a dental setting may elicit heightened subjective pain responses.

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Introduction.

Investigation of acute pain conducted in the research laboratory helps to confirm that pain is a multi-dimensional perceptual experience, involving one's longstanding beliefs and, perhaps most critically, current cognitive mental processes. Dental pulp stimulation has been used for many of these experimental pain studies. Chapman *et al.*[1] have applied the sensory decision theory to analysis of subjective human pain reports in response to electrical tooth stimulation. Chen[2] has shown that the cognitive status of believing or not that one has taken a mild analgesic modifies response to tooth pulp stimulation. Barber and Mayer[3] have evaluated the efficacy and neural mechanisms of hypnotic analgesia procedures when experimental tooth pulp pain was produced by electrical stimulation. Klepac *et al.*[4] have correlated sensitivity to dental pulp shock with apprehension over receiving dental treatment. More recently, several laboratories have investigated brain-related evoked potentials associated with painful tooth pulp stimuli, coupled with acupuncture, nitrous oxide, and narcotics.[5,6]

However, laboratory studies have been criticized for their limited generality. Although some methods for producing laboratory pain are claimed more realistic,[7] many clinically-oriented therapists and researchers have argued that laboratory studies of pain do not have meaningful consequences for the research subject.[8] Laboratory pain research, for example, uses volunteer subjects who do not arrive in pain or expect to leave in pain; moreover, there is an explicit assurance that no permanent tissue damage will occur, and that artificial pain stimulation will carry no lasting effects. Pain data gathered in the laboratory, therefore, may have limited generalization to pain reports actually encountered in clinical settings.

Unfortunately, very few controlled studies have been undertaken to examine whether or not individuals modify their reactions when pain is experienced in clinical settings contrasted with laboratory-induced pain. It has been suggested that the situational context of a dental treatment setting may fulfill the major requirements of an experimental laboratory for pain research, while simultaneously lending significance to the pain experience. One value of the dental setting used in this way is that controlled experimental tooth pulp pain can be produced in both settings, which is indistinguishable from clinical tooth pulp pain in neuro-anatomical sites stimulated and the types of subjective pain reports which can be gathered.

An experiment was developed to test the theory that a situational context could be designed in which pain behavior would acquire real meaning for the subject, specifically by carrying implications of dental treatment or dental disease. A pain research laboratory and a clinical dental environment were selected as contrasting situational contexts in which the same painful stimulus could be embedded. It was anticipated that under appropriate experimental conditions, the dental environment would be appraised as more threatening or harmful. Lazarus[9] has demonstrated that appraisal of threat or harm is associated with marked increases in apprehension and lowered tolerance for aversive stimuli, including pain. Accordingly, we hypothesized that when the same electrical tooth pulp stimulation was applied in laboratory and clinical dental contexts, lower stimulus intensity would be required in the dental setting to reach pain threshold and pain tolerance levels.

Materials and methods.

Subjects. – Sixty-six volunteer females, recruited from graduate courses in nursing, in good physical and mental health, and ranging in age from 22 to 31 yr ($\bar{X}$ = 24.4, s.d. = 6.2), participated in the study.

Experimental design and procedures. – A repeated measures design was used. Responses to pain were recorded on two occasions for each subject. The first occasion was in the psychological laboratory and was identical for all subjects. This served as the control session. Subjects were then randomly divided into two groups prior to being tested again in a second or experimental session.

Control session. – Instructions were given to the effect that we "would be testing reactions to stimulation – in this case, electrical stimulation to a tooth." The subject was assured that it was an often-used and harmless procedure, and that she would be able to stop the stimulation by an appropriate signal.

Experimental session. – Lab-Lab (LL) Group (N=33). Subjects assigned to the LL group were advised to appear at the laboratory again to complete their part in the experiment. They were reminded they would be paid when finished. The same procedures on the same tooth as for the initial session were completed on each LL subject. After all measures were recorded, subjects completed a post-experimental questionnaire designed to provide information regarding their perceived conception of the purpose of the experiment, and to inquire more directly into reactions to having a tooth tested. Each subject was then fully debriefed regarding the nature of the study.

Lab-Dent (LD) Group (N=33). For this group, the physical environment and instructions were altered to introduce a "real life" context for measuring responses to

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tooth stimulation. The experimenter now identified himself as a dentist evaluating several methods of determining whether teeth were healthy or not. It was further explained that the best method for assessing tooth vitality is the electrical pulp testing procedure she had undergone; thus, responses to electrical stimulation of her tooth might be an indication of the tooth's current health. To further enhance the realistic nature of her participation, each subject was asked to come to a dental office nearby. At the dental office, she was seated in a conventional dental operatory, the tooth was examined by mirror and explorer, and the name of her personal dentist was obtained. The same steps were followed as in the control session to obtain measures of pain responsivity. Each subject then completed the post-experimental questionnaire. Finally, subjects were fully debriefed regarding the nature of the pain study.

Pain stimulation method and procedure. – The pain stimulus was electric current delivered to an isolated and dried tooth *via* a circular conducting probe 3 mm in diameter (surface area = 9.42 mm^2). The probe was coated with conducting paste to ensure uniform contact. The source of the current plus a ground electrode and probe together constituted a clinical pulp tester.§ Sold commercially, it is capable of delivering a reliable, well-calibrated current to the probe ranging from 1-100 μA. The apparatus was modified for purposes of the present experiment, to provide constant current and continuous dial readings whether or not the probe contacted the tooth.

Responses to a painful stimulus were defined in three types of reports:

(1) Absolute Sensation Threshold (AST) – the first onset of any physical sensation;
(2) Pain Threshold (PTh) – the first onset of pain; and
(3) Pain Tolerance (PTo) – that point at which pain was no longer tolerable.

Data analysis. – Stimulus intensity was the major dependent variable, measured as the amount of electrical stimulation, in μA, to the tooth. Threshold and tolerance levels for each subject consisted of the average of ten ascending limits trials conducted in both the laboratory and dental treatment setting. Data were subjected to analysis of covariance, with each subject's initial or control session responses as the covariate.

§S.S. White Dental Manufacturing Company

The post-experimental questionnaire was submitted to Chi-square analysis to evaluate subjective responses to tooth pulp shock in the different situational contexts.

Results.

The Table contains the mean stimulus intensities (μA) for the LL and LD groups for both sessions. The two groups were not significantly different on initial levels of AST, PTh, and PTo. For the LL group, all stimulus intensity values (AST, PTh, PTo) were slightly higher on the second laboratory testing. Derived pain range measures were also larger for the second test sessions. None of these findings for the LL group was statistically significant.

The Table also contains the mean stimulus intensities (μA) for the LD group, for both the control session and the dental sessions. A significant decrease in absolute sensation threshold ($\bar{X}_C$ = 4.12 *vs.* $\bar{X}_D$ = 3.82, $p < .05$), pain threshold ($\bar{X}_C$ = 5.90 *vs.* $\bar{X}_D$ = 4.88, $p < .005$), and pain tolerance ($\bar{X}_C$ = 13.38 *vs.* $\bar{X}_D$ = 9.12, $p < .001$) was noted, when these subjects were tested in the dental environment compared to their pain responses in the laboratory. Accompanying these significant changes in pain reports were significant constrictions of the various pain ranges that were computed (Table). These results clearly indicate subjects were more sensitive to electric tooth shock in the dental setting than in the laboratory.

The final analysis contrasts the second session for both groups (Table). Analysis of covariance of the second session stimulus intensity data reveals significant lowering of absolute sensation threshold ($\bar{X}_C$ = 4.53 *vs.* $\bar{X}_D$ = 3.82, $p < .05$), pain threshold ($\bar{X}_C$ = 6.48 *vs.* $\bar{X}_D$ = 4.88, $p < .003$), and pain tolerance ($\bar{X}_C$ = 13.90 *vs.* $\bar{X}_D$ = 9.12, $p < .001$) levels for the LD group compared to the LL group. In terms of percent change, when the subject is used as her own control, stimulus intensities for the absolute sensation level are 15.7% lower, on the average for the LD group. Similarly, pain threshold is 24.6% lower and pain tolerance is 34.6% lower when these values are determined in the psychological laboratory. This analysis of the second session reveals that subjects tested in the clinical setting show heightened sensitivity to pain, compared to subjects tested in the laboratory.

Direct evidence was gathered by questionnaire which

TABLE
MEAN STIMULUS INTENSITIES (μA)
(1) Laboratory Context: Comparison of Laboratory Session 1 and Laboratory Session 2 (LL Group)
(2) Dental Context: Comparison of Laboratory Session 1 and Dental Session 2 (LD Group)

Stimulus Intensity Level	(1) Laboratory Context		*P*	(2) Dental Context			*P*
	1* (Lab)	2 (Lab)		1* (Lab)	2 (Dent)		
Absolute Sensation Threshold (AST)	4.49	4.53	.800	4.12	3.82	$\bar{X}$	.050
	2.86	1.35		2.54	1.52	s	
Pain Threshold (PTh)	6.24	6.45	.500	5.90	4.88	$\bar{X}$	.050
	4.08	2.26		2.34	2.24	s	
Pain Tolerance (PTo)	12.25	13.90	.100	13.38	9.12	$\bar{X}$	.005
	8.03	8.19		9.36	7.09	s	
Ranges							
PTo – PTh	6.01	7.42	.100	7.48	4.24	$\bar{X}$	.010
	7.76	7.76		8.47	5.86	s	
PTh – AST	1.75	1.91	.100	1.78	1.06	$\bar{X}$	.010
	2.60	1.84		1.48	1.23	s	
PTo – AST	7.76	9.37	.100	9.26	5.30	$\bar{X}$	.010
	7.93	8.80		9.69	5.82	s	

*n.s. difference, LL and LD groups for first (Lab) session.

confirms that the dental environment was indeed perceived as more anxiety-producing. In response to the direct post-experimental question: "During which of the two sessions did you feel more anxious?," five subjects, or 15% of the LL group, claimed the second (laboratory) session to be more anxiety-provoking. Twenty subjects, or 70% of the LD group, found their second (dental) session more anxiety-provoking. The Chi-square difference is significant (S^2 = 4.91, $p < 0.03$), indicating that, when the second session was the dental situation, it was seen as significantly inducing greater anxiety.

Additional questionnaire data also lends support to these findings. At the end of the second session, subjects were asked whether they were able to make a distinction between absolute sensation ("the first thing you feel") and the subsequent trials for pain threshold ("when you first feel pain"). Of the 33 LL subjects, 16 felt they could not distinguish absolute sensation from the first feeling of pain (*i.e.*, pain threshold), while 17 claimed they could make such a distinction. For the LD group, 25 felt they could not make the absolute sensation-pain threshold distinction, while only eight felt they could. This difference is significant (X^2 = 5.20, $p < 0.25$), indicating that the capacity to distinguish an initial sensation from early pain was dependent on the testing situation.

Finally, subjects were asked afterward whether they could, indeed, have taken more pain. Nine subjects in LL group (28%) claimed they could not have taken more pain; by contrast, 16 subjects (48%) in the LD group reported they could not have taken more pain. This difference was significant (X^2 = 5.17, $p < 0.04$) suggesting that willingness to exceed pain tolerance depends on the situation.

Discussion.

The manipulation of a pain setting from a research laboratory to a dental operatory yielded significantly lowered absolute sensation thresholds, pain thresholds, and pain tolerance levels, when the same individuals had the same teeth tested with an identical source of tooth pulp stimulation. The capacity of changes in situational context to lower pain thresholds is attributed to cognitive mental processes which yield different meanings for laboratory pain and clinically relevant pain.

The meaning of dental pain in a dental setting could derive from past experience in that pain-producing setting, or other psychosocial and learning possibilities. For example, pain perceived as having clinical/diagnostic significance might mean the threat of dental treatment, impaired physical appearance, or loss of function. In any case, when clinicians encounter patients in settings associated with pain, they are often aware of powerful, generally non-observable factors which shape the context for individual responses to noxious stimulation. Laboratory pain experiments may not allow the same contextual significance for the pain experience. For acute pain, the anticipation of threat or harm, generally observed as anxiety, seems to consistently emerge as a prepotent cognitive mediator of pain behavior. The capacity for dental environments to elicit anxiety is well enough known. Such situational anxiety was shown to disrupt a cognitive task (anagram solution of "orally"- and "non-orally"-related words) in the dental setting. Completion of the same cognitive task took longer and was associated with more anxiety in the dental setting, compared to a neutral environment.[10]

Our study also addressed a controversy of many years regarding the possibility that tooth stimulation can elicit sensations other than pain. The data confirm the by-now-clear evidence which indicates that one is capable of detecting so-called pre-pain sensations in teeth. Interestingly, our data also reveal that the detection of an absolute threshold for sensation in teeth was clearly more evident in the laboratory than it was in the dental setting. One component of the overall pain range, the absolute sensation-pain threshold range, is therefore of particular interest because of its significant constriction in the dental setting.

In the dental setting, the range between absolute sensation threshold and pain threshold is almost half the laboratory range. Heightened anxiety may obliterate the ability of many people to maintain a distinction between a pre-pain sensation and pain sensation, in the context of the pain-producing dental setting.

Conclusions.

The major focus of the present study was to demonstrate that one's response to pain may be altered according to the situational context in which pain is encountered. It was demonstrated that absolute sensation threshold, pain threshold, and pain tolerance levels are all modifiable as the context for pain changes. This is the first study to experimentally support the contention that a clinical pain-producing situation yields heightened pain and increased sensitivity compared to that experienced in a pain research laboratory.

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