The effect of auditory stimulation on blood pressure changes associated with pain

FRANK H. FARLEY
UNIVERSITY OF WISCONSIN[1]

The effects of auditory stimulation on systolic blood-pressure (SBP) increases elicited by the cold pressor procedure were studied in seven Ss, each S acting as his own control. It was found that auditory stimulation significantly depressed SBP over a no-stimulation control condition

Gardner & Licklider (1959) have reported that subjective pain occurring during dental drilling without local or general anesthetic was markedly decreased by white noise delivered binaurally. Completely effective analgesia, as gauged from subjective reports, was obtained in 63 percent of the 387 patients studied. Further investigations reported by these authors have involved variations in the auditory stimuli and the use of other pain-eliciting procedures including minor surgical operations and labor and child-birth. Results in these subsequent studies have been essentially the same as in the earlier work. The phenomenon of audio-analgesia is now widely known and employed in the practical control of subjective pain.

One of the important problems set by the work on audio-analgesia is that of understanding the mechanism(s) of the analgesic effect. It might be argued that some form of attentional shift was operating and reduced the perception of the painful stimulus, consequently reducing the perceived intensity of pain. An extension of such a model as Broadbent's (1958) might be applicable.

An equally important and related question concerns the possible identification of physiological concomitants of audio-analgesia which, if successful, might aid in understanding the mechanism(s) of the audio-analgesic effect, as well as provide an objective measure of audio-analgesia replacing the subjective pain response.

A reliable physiological concomitant of pain as elicited by the cold pressor test is an elevation in blood pressure (McMurray & Jacques, 1959; Wolff, 1951). These authors and others have shown that subjective pain is an essential component in response to the cold pressor test, and that this procedure elicits a reliable and characteristic rise in blood pressure. The perception of pain, then, is correlated with an increase in blood pressure.

It was of interest to establish whether audio-analgesia acted both on the perception of pain *and* on the pain-related changes in blood pressure. On the basis of the work reviewed above, the following study was undertaken with the expectation that auditory stimulation might decrease *both* SBP and the subjective pain response during the cold pressor procedure.

Method

Seven undergraduate students (five male, two female) naive with respect to the purpose of the experiment were employed as Ss. The age range was 18-24 years with a median of 21 years. No S reported a medical history suggesting cardio-vascular disease, abnormal blood pressure, insensitivity to pain, hearing difficulties, etc.

A Cambridge Instrument Company recording sphygmotonograph was used for the continuous measurement of systolic blood pressure (SBP). A 4000-l beaker filled with continuously stirred ice and water at 1°-4-1/2°C was employed in the cold pressor procedure. Auditory stimulation of a fixed frequency of 130 cps and a fixed intensity of 90 dB was produced by a Heath Model 200 AB audio-oscillator, with the auditory stimulation manually controlled by E and delivered binaurally using earphones.

An experimental design was used in which each S acted as his own control. Each S received one condition of 3 min. duration—that is, the cold pressor test with (or without) acoustic stimulation, followed by a 10 min. rest, and then the remaining condition of 3 min. duration—that is, the cold pressor test without (or with) acoustic stimulation. The experimental condition was differentiated from the control condition by the presence of auditory stimulation in the former. Three Ss received the experimental condition before the control condition, while four Ss received the reverse of this procedure, with the order being alternated across Ss. It is worth noting where the present design is concerned that Hines & Brown (cited by McMurray & Jacques, 1959), McMurray & Jacques (1959) and Wolff (1951) have reported that the value of the increase in blood pressure associated with the cold pressor test is unaffected by previous tests.

The test sessions for all Ss were conducted in the same room under undisturbed conditions; instructions were the same for all Ss. All testing was done by one E.

Each S was seated confortably and the sphygmotonograph cuff was attached high on the left arm. Headphones were fitted firmly over both ears; this was done in both the experimental and control conditions. Blood pressure recording was begun before immersing the S's right hand to wrist height in the beaker, and in the experimental condition the auditory stimulation was delivered at the onset of hand immersion.

Recording of SBP was taken for 3 min. under each condition, with a 10 min. rest period between condi-

tions during which time no apparatus was attached to S. Following termination of the second condition, S was requested to report on any subjective differences noted between the two conditions.

The procedure used in handling the SBP recordings was that employed by McMurray & Jacques (1959) in which the point of hand immersion was designated as 0 min., and SBP read in mm of mercury at approximately every 30 sec. throughout the (3 min.) record. The mean of the resulting six readings for each S under each condition was entered into the statistical analysis.

Results and Discussion

The experimental mean SBP was lower than the control mean SBP; this difference achieved significance on a t-test for correlated means ($t = 2.29$, $df = 6$, $p < .05$).

Turning to the subjective reports of pain, it was found that two Ss definitely felt less pain under the experimental condition than under the control condition, two Ss reported slightly less pain under the experimental condition, and the final three Ss reported no difference between conditions. It is interesting that those Ss showing the greatest difference in SBP between the two conditions (SBP lower under the experimental condition) were the Ss who reported less or slightly less pain occurring during the experimental condition. (All Ss reported that the cold pressor procedure elicited pain.)

The lack of a clear-cut audio-analgesic effect suggests that where the perception of pain was concerned, the (pure tone) auditory stimulus was not entirely effective, and that something closer to the random noise employed by Gardner & Licklider (1959) would be preferable. However, the remaining findings of the study are provocative in indicating that the auditory stimulation *was influencing* SBP in some unspecifiable direct or indirect manner.

A body of research that seems related to the present work is that on autonomic response patterning (Lacey, Kagan, Lacey, & Moss, 1963). Lacey et al have shown that under conditions in which S is required to attend to environmental input ("environmental intake" situation), blood pressure decreases and heart rate deceleration occurred, but under conditions that seemed more to involve inattention to or "rejection" of environmental stimulation (eg., during periods of "mental work") blood pressure increases and heart rate acceleration were noted. Photic (flash) stimulation reduced blood pressure and decelerated heart rate. Unpleasant white noise ("...flucuated irregularly in loudness, reaching peak intensities in excess of 100 dB above threshold." Lacey et al, p. 172) produced heart rate deceleration, but elicited a modest *rise* in blood pressure. Reasons for the latter finding were not discussed by Lacey et al. Given that white noise produced but a small rise in blood pressure, one may speculate that a pure tone as used in the present study, being less unpleasant than a white noise such as that of Lacey et al (which would lead to "rejection" of such environmental stimulation) would demand "attention" rather than "rejection" and accordingly would be associated with *decreased* blood pressure. Such a pure tone then would have an effect closer to that of flash stimulation than that of white noise. This is, of course, mere speculation, and if no less, the results of Lacey et al in which white noise slightly increased blood pressure, taken in conjunction with other work suggesting increased blood pressure under intense auditory stimulation (Woodworth & Schlosberg, 1954) make the present finding of yet greater interest.

One other possible interpretation that cannot unequivocally be ruled out stems from the degree to which pain is subject to suggestion, in that it may in the present case be to some extent the suggestive effect of the additional stimulus, rather than the effect of the sound itself, that was measured.

For the present, this study indicates the possibility of using an objective measure of audio-analgesia (decreased SBP) as opposed to the subjective measure of felt pain.

Clearly, further research is required, and should include larger samples, variations in the auditory stimulus, pain eliciting procedures other than the cold pressor test, and a necessary control condition in which the effects of auditory stimulation on SBP per se are studied, without a pain elicitation procedure.

References

Broadbent, D. E. *Perception and communication.* London: Pergamon Press, 1958.

Gardner, W. J., & Licklider, J. C. R. Auditory analgesia in dental operations. *J. Amer. Dent. Ass.*, 1959, 59, 1144-1149.

Gardner, W. J., Licklider, J. C. R., & Weisz, A. Z. Suppression of pain by sound. *Science*, 1960, 132, 32-33.

Lacey, J., Kagan, J., Lacey, B. C., & Moss, H. The visceral level: situational determinants and behavioral correlates of autonomic response patterns. In *Sym. on the expression of emotions in man.* Int. University Press, 1963. Pp. 161-196.

McMurray, G. A., & Jacques, L. B. Capillary resistence and blood pressure changes associated with pain due to local cooling; cold pressor test. *J. appl. Physiol.*, 1959, 14, 813-816.

Wolff, H. H. The mechanism and significance of the cold pressor response. *Quart. J. Med.*, 1951, 20, 261-273.

Woodworth, R. S., & Schlosberg, H. *Experimental psychology.* New York: Henry Holt, 1954.

Note

1. This research was undertaken at the University of Saskatchewan, Canada.