Reports

Sound Stimulation and Its Effect on Dental Sensation Threshold

Abstract. The success of "auditory analgesia" in dental operations may be a result of distraction, suggestion, or cross-sensory masking, or of a combination of the three. An attempt to separate these influences was made by measuring the change in sensitivity to electrical stimulation of the teeth in typical dental patients upon presentation of loud white noise. No differences in this "tingle" threshold under noise and no-noise conditions were found, either when preliminary instructions were neutral or after implicit or explicit suggestion that the noise would raise the threshold. These results indicate that auditory analgesia is probably not an example of cross-sensory masking, and that its successful use in the clinical situation depends both on distraction and on suggestion.

The use of auditory stimulation as an analgesic agent in clinical situations has been a topic of considerable interest since the appearance of the Gardner and Licklider article (*1*). That "auditory analgesia" is often effective and can supplement or replace conventional analgesics in ordinarily painful procedures, such as dental operations, has been amply demonstrated (*1, 2*).

However, just how this effect occurs —whether by direct neural interaction (cross-modality "masking" of pain impulses by massive firing of neural elements in the entire auditory pathway), by distraction (since attention-attracting music and noise are used in actual practice), or by suggestion (a factor generally involved in that most individual of personal experiences, the perception of pain)—is not at all clear. Indeed, although the intensity of a suprathreshold pain seems to be reduced by auditory stimulation, it has not yet been established that the threshold for pain is shifted. As the first step in an attempt to isolate the significant parameters of this phenomenon, a series of experiments was undertaken to study the effects of broad-band noise on the sensitivity of teeth to electric stimulation. Although the tingling sensation that is felt in a tooth upon application of an electric current at threshold intensities may not be "pain," strictly speaking, at least the neural chain concerned is the one involved in dental surgery, so we felt that the approach had some face validity. If cross-sensory masking is the principal cause of the reduction of pain in audio analgesia, the noise might reasonably be expected to raise the "tingle" threshold as well.

In all the experiments of the series one tooth from each of six dental areas was selected at random for testing, once with and once without noise. The order of testing was also random, with two restrictions: (i) each of the six teeth was tested once before retesting began, and (ii) there were no successive tests on the same tooth. Electrical stimulation was provided by a commercial high-frequency pulp tester, or vitalometer, found to be reasonably reliable in terms of patient response (*3*). Three experimenters were involved in the threshold determinations. The first, E_1, consulted the predetermined schedule and called out the number of the tooth to be tested to E_2, who applied the electrode of the vitalometer to the tooth. At this time E_1 turned on the noise in the subject's earphones, if noise was scheduled. When the electrode was in place, E_3 began applying electrical stimulation to the tooth, gradually increasing the intensity of a continuous current until the subject indicated, by raising his finger, that he felt a "tingle." Experimenter E_3 then called out the setting on the arbitrary scale of the tester to E_1, who recorded the number and called out the next tooth. Experimenter E_3 wore a pair of earphones that transmitted music at a level high enough to mask out environmental auditory events. For E_2 to be unaware of the sound condition was not considered critical. He was not specifically prevented from hearing the noise if it was on; however, the pulp tester itself made enough noise to mask noise leakage from under the subject's headset. The final datum for each tooth was the shift in scale reading under the noise condition. A positive score therefore indicated that a higher voltage was required to elicit a response when the noise was on.

In the first experiment 19 dental-clinic patients (selected at random) who had just been given routine diagnostic examinations were brought in "for additional tests" on their teeth. No other instructions were offered, and questions were answered noncommittally. A noise at 100 db SPL (that is, one whose sound pressure level is 100 db above 0.0002 dyne/cm^2) was provided by a commercial analgesia apparatus. In addition to the experimental group, a control group of six subjects to which noise was transmitted whenever the electrical stimulus was applied and of six subjects to whom no noise was transmitted during any of the 12 applications was also tested; as it turned out, this control was unnecessary.

Of the 114 scores in the experimental group, 15 had to be discarded because there was no response even at the highest setting of the vitalometer. The remaining 99 scores showed a chance distribution: 42 were positive, 42 were negative and 15 were zero. The possibility was considered that some subjects might consistently show a positive shift and others a negative shift. If this were true, a tendency toward bimodality in the distributions of scores should have been evident. However, the distributions of scores for both experimental and control groups were entirely normal and had nearly identical slopes when plotted on probability paper.

There were no differences in results for male and for female patients.

The experiment was repeated with 14 subjects and with a 120-db-SPL broad-band noise provided by another commercial audio-analgesia apparatus. Of the 84 scores, 33 were positive, 39 were negative, and 12 were zero, again a chance result. In short, there was no significant shift in threshold under a condition of high-intensity noise. These results are consistent with those obtained by Weisz and his co-workers (*4*), using a variety of painful stimuli.

The failure to find shifts in threshold means that the hypothesis of cross-modality masking will not serve to explain the effectiveness of audio analgesia in diminishing suprathreshold pain unless one postulates different neural pathways for the transmission

of threshold and suprathreshold stimuli. Some investigators (*5*) have reported that in addition to the direct somesthetic sensory impulses going directly to the cortex there are secondary impulses that reach the cortex via the reticular formation. Perhaps stimulation at threshold may not activate this secondary system, although the possibility seems somewhat remote.

To study, next, the possible effect of suggestion, another experiment, in which different degrees of suggestion were utilized, was performed. In one group of eight subjects (the implicit suggestion group), each subject was read a statement to the effect that stimulation was to be applied to his teeth under conditions of noise and no noise, and that some people believed they would not feel a given amount of stimulation as much when the noise was on. Auditory analgesia was discussed extensively with another group, of 15 subjects (the explicit suggestion group), who were made aware that E_2 (who applied the electrode to the teeth) believed that they would not feel a given amount of stimulation as much when the noise was on. Broad-band noise at 120 db SPL was used.

Of the 48 possible scores in the implicit suggestion group, 2 were discarded because of no response at the highest setting of the vitalometer, 24 were positive, 16 were negative, and 6 were zero. Of the 90 possible scores in the explicit suggestion group, 4 were discarded due to lack of response, 45 were positive, 33 were negative, and 8 were zero. In neither suggestion group was the shift statistically significant. Even when scores for the two groups were combined, the rise in threshold, with noise, did not reach the .05 confidence level (χ^2 with $\eta = 1$). Again, no sex differences were found.

Thus, there is no evidence that noise reduces sensitivity when a tooth is stimulated electrically, and there is only a hint that suggestion may raise the threshold slightly. Of course one must, in interpreting the results, keep in mind the artificiality of the laboratory setting. In this tooth-vitality testing situation, subjects can be expected to focus their attention on the tooth being tested, thereby minimizing the effects of the third possible cause of the audio-analgesic effect—distraction. In addition, the attitude of the typical subject toward a test situation of relatively finite duration and his attitude toward an operative procedure of uncertain duration and unknown severity are probably quite different. It seems likely that the subject would respond more to suggestions of decreased sensitivity in the latter, more anxiety-arousing, situation. Perhaps the effectiveness of auditory analgesia in a clinical situation depends on both suggestion and distraction, acting jointly (*6*).

SIDNEY CARLIN, W. DIXON WARD*
ARTHUR GERSHON, REX INGRAHAM
Human Factors Research Division, School of Dentistry, University of Southern California, Los Angeles

References and Notes

1. W. J. Gardner and J. C. R. Licklider, *J. Am. Dental Assoc.* **59**, 1144 (1959).
2. H. Cherry and I. M. Pallin, *Dental Dig.* **54**, 455 (1948); W. J. Gardner, J. C. R. Licklider, A. Z. Weisz, *Science* **132**, 32 (1960).
3. P. P. Taylor, *Oral Surg. Oral Med. Oral Pathol.* **6**, 1020 (1953).
4. A. Z. Weisz, personal communication.
5. J. D. French, M. Verzeano, H. W. Magoun, *A.M.A. Arch. Neurol. Psychiat.* **69**, 519 (1953).
6. Supported by research grant D-1488 from the National Institute of Dental Research, U.S. Public Health Service.
* Present address: Department of Otolaryngology, University of Minnesota, Minneapolis.

26 October 1962

Gas-Flow Counting of Carbon-14 Compounds: An Improved Technique

Abstract. Reproducibility in counting by a gas-flow detector of duplicate samples of C^{14}-labeled compounds plated on glass planchets is much improved by spraying of the lower surface of the planchet with an "antistatic" agent in aerosol form. Count rates that decreased with time were eliminated by this treatment.

Recently it became necessary to determine accurately the disintegration rates of C^{14}-labeled samples of higher radioactivity than those previously used in our work. These samples were plated in very thin layers on glass planchets and counted in a windowless methane gas-flow detector operating in the proportional region at an absolute efficiency of 50 percent. With samples showing an activity of about 500 count/min, reproducibility between duplicate planchets approximated the statistical fluctuations (2 percent reliable error) expected from the total number of counts accumulated. With samples showing an activity of 50,000 count/min, however, not only was reproducibility between duplicate planchets far worse than could be explained by the random nature of the disintegration but also the count rates decreased with successive 1-minute counts.

Since the proportional detector was used in conjunction with a fast amplifier and scaler (resolution time, 0.8 μsec) and an electronic timer, coincidence losses or instrument errors could not account for these variations. The count rate, which decreased rapidly for the first few minutes then gradually ceased to change, was restored to its original higher value if a planchet was removed from the chamber with forceps, placed for a moment on any surface, such as a wooden bench or a hand, and replaced in the chamber. The count rate would then again decrease in a similar manner. If the planchet was removed from the chamber with forceps and replaced in the chamber without allowing the lower surface of the planchet to touch any other surface, the count rate immediately observed was the lower "equilibrium" rate. These effects were also observed when the same planchets were counted in another type of gas-flow detector which had a very thin window and operated in the region of the Geiger counter.

Similar types of errors have been noted by others when I^{131} was plated on cupped aluminum planchets (*1*), S^{35}, P^{32}, and Cs^{137} on planchets of copper, glass, aluminum, or steel (*2*), C^{14} on aluminum or brass planchets (*3*), and H^3 on nickel planchets (*4*). Various explanations of these errors have been offered (*4–6*) and remedies have usually involved some treatment of the upper surface of the planchet to render it conducting. Thus Spang and Gebauhr evaporated a thin layer of silver onto the planchet (*6*); others mixed colloidal graphite with the sample prior to its plating (*1, 3, 4*). These remedies have the disadvantage of contaminating the sample, a consideration that is important when the sample must be recovered after counting.

We have found that spraying the lower surface of a glass planchet with certain of the aerosol mixtures sold in music stores for removing the static charge from vinyl phonograph records completely eliminates the problem of count rates that decrease with time, so that counts on either the sample or duplicate samples may be reproduced with an error only slightly greater than that expected. The data in Table 1 show typical results obtained when a sample of C^{14}-labeled photosynthate from wheat leaves, plated from 80 percent aqueous ethanol, was counted in the proportional counter over a period of time and then recounted after the lower surface had been lightly sprayed