THE EXPERIMENTAL MODIFICATION OF SONOROUS BREATHING

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Loud snoring is a noxious habit and potential personal health risk. We are reporting the first experimental study of simple behavioral techniques for the modification of chronic snoring. Twenty-four volunteers participated in a repeated measures, randomized group design over 2 weeks of intervention and one-month follow-up. Treatment groups included a contingent-awakening and breathing retraining (self-control) condition. Both treatment groups were compared to a no-treatment control. Despite considerable intra-subject variability and the lack of an adequate attention-placebo control group, objective assessment indicated a substantial reduction in snoring amplitude and frequency in both treatment groups. Follow-up assessments further demonstrated maintenance of change. This study has implications for modification of sleep habit disorders and learning without awareness.

DESCRIPTORS: snoring, suppression, control, behavior modification

The conditioning approach to sleep habit disorders dates back to the pioneering work of Mowrer (1938) in his treatment of nocturnal enuresis. Since that time direct modification of bed-wetting and bruxism (teeth-grinding), another sleep habit disorder, has been accomplished with response contingent awakening procedures (Mowrer, 1938; Heller & Strang, 1973). The present study was based on the hypothesis that contingent awakening procedures could be successfully applied to noxious snoring.

Snoring, also known as sonorous or stertorous breathing, may be operationally defined as "any intense audible sound in the upper respiratory passage of the sleeper" (Boulware, 1966). Despite the ubiquity of the phenomenon, a dearth of data and a plethora of humor surround the subject of snoring. Snoring is universal in occurrence and incidence estimates range from 10 to 20% of the population (Boulware, 1967).

Sonorous breathing is a common source of in-

terpersonal discomfort and occasional health consequences. Loud periodic snoring may also be a critical symptom of sleep apnea, which involves a cessation of respiration during the night. The consequences of sleep apnea are serious hypersomnia and other cardiovascular symptomatology (Weitzman, Pollak, Borowiecki, Burack, Shprintzen, & Rakoff, 1977). Even when snoring is unrelated to sleep apnea, it is generally regarded as a noxious habit and a troublesome family problem.¹

Most snoring is produced by vibration of the soft palate or the faucial pillars during inspiration (Boulware, 1966). Clinically, two categories of snoring may be differentiated: pathological and functional. Pathological snoring can be attributed to a variety of structurally based or disease-related respiratory obstructions (e.g., a deviated septum, allergic conditions, infected tissues). On the other hand, most snoring occurs in the absence of any clear physical pathology. In-

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¹This research program arose out of the common complaint of clients in sex therapy that loud snoring of one spouse or the other required the use of separate bedrooms.

stead, a wide range of personal habit factors, such as obesity, smoking, diet, fatigue, and sleep position, may be influential.

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Unvalidated attempts to modify snoring have included the over 300 patented antisnoring devices, autosuggestion (Horwich, 1950), bibliotherapy (Boulware, 1974), and psychoanalysis (Altshuler, 1964). Another cluster of treatment approaches have directed their attention to aiding the snorer's spouse by suggesting earplugs, separate bedrooms, sedatives, and warm baths (Boulware, 1969). Along these lines, a recent case study reported the use of behavioral fading techniques to reduce a female client's aversion to her fiance's snoring (Koebel & Crist, 1977). To date, no studies have been reported in which snoring is directly modified using environmental contingencies.

The hypothesis to be investigated in this study was that response contingent awakening could be used to suppress noxious snoring. This study was also intended to evaluate the efficacy of a less direct, "self-control" program, involving a variety of breathing and muscular exercises carried out in the waking state.

METHOD

Participants

Twenty-four participants (20 males, 4 females) ages 33 to 50 (mean = 42 yr) were selected from those responding to advertisements placed in local newspapers. Prospective participants were screened by physicians to exclude from the study anyone showing symptoms of ENT pathology. Eight were rejected on this basis, one of whom was referred to a sleep disorder center for evaluation of serious sleep apnea. He was subsequently diagnosed as having life-threatening apnea and a tracheostomy was successfully performed.

All applicants were interviewed and accepted

only if they reported the following: (a) a history of daily, "disturbing" snoring; and (b) body weight below 200 pounds (to exclude individuals with the "Pickwickian Syndrome").

Procedure

A repeated measures design was used. The treatment phase of the study lasted 2 weeks. Each participant, following an initial interview, was randomly assigned to one of three conditions:

1. Contingent-awakening (CA) group received an experimental device for home use.
2. Self-control (SC) group were instructed in techniques of effective breathing and throat muscle-tonus control.
3. No-treatment [waiting-list (WL)] control group.

Objective audiotape assessments of snoring were obtained prior to treatment, after 1 week of intervention (midpoint), and at the end of the 2-week program. Experimental participants were also evaluated 1 month after treatment. WL control participants were offered immediate treatment after the 2-week waiting period had ended. The lack of a 1-month follow-up tape for the WL control group resulted in an unfortunate limitation in the study's design. Self-report questionnaires were completed by all experimental participants before and after treatment and at the 1-month follow-up.

Contingent Awakening

The response suppression apparatus constructed for this study² consisted of a sensitive microphone, a voice-activated relay (VAR), a response lever, and a cumulative counter. In addition, a calibrated dial allowed for adjustment of the VAR threshold within an approximate range of 60 to 85 decibels. As the subject's snoring exceeded the VAR threshold, a high amplitude tone signal of oscillating frequency (to minimize habituation) was continuously pre-

²We are much indebted to Zoltan Sisko for construction of this apparatus.

sented until the participant awakened and depressed the response lever. Each response advanced the cumulative counter, terminated the tone, and initiated a 30-sec refractory period (to prevent multiple activation).

The modification program was begun at the *least* sensitive setting, and the sensitivity increased each time the participant recorded *less* than seven responses per night. No change in the threshold was made if the participant recorded seven or more responses.

Self-Control

The self-control treatment instructions were recorded on two sequential 15-min cassette tapes and consisted of a muscle tonus control and breathing retraining program to modify the faulty breathing patterns thought to influence snoring. Participants were instructed to listen to the tape prior to bedtime and practice certain exercises throughout the day. Both tapes included progressive relaxation, breathing, jaw, and phonetic exercises designed to enhance awareness of breathing patterns and impart tonus to the pharyngeal structures. An autosuggestion formula (i.e., "I will not snore") and personal habit restrictions (e.g., reduction of alcohol and salt intake) were also offered to this group only.³

WL Control Group

Participants were told that effective treatment required a comprehensive evaluation of their snoring problem. This group was retested after 2 weeks and then offered treatment.

Dependent Measures

As Mark Twain observed, "There ain't no way to tell why a snorer can't hear himself snore." Because self-report of snoring is notoriously inaccurate and unreliable, corroborative objective measures of snoring in the natural environment are essential. In the present study, the following multiple assessments were used:

1. Audiotapes of the first 3 hours of the

night's sleep were made by the participant in his or her home with a Sony (Model TC-377) tape recorder and Realistic (1800') tape. The microphone was positioned 2' (.6 m) above the subject's pillow for all recordings. Snoring sounds were converted into electrical resistance and displayed on a Beckman Type R polygraph during playback. Each tape began with a calibration signal of constant amplitude (80 db at 2') which functioned as a reference standard, permitting calculation of relative snoring amplitudes.

2. For the contingent-awakening group, the number of VAR activations per night and the sensitivity dial setting (unit threshold) were also recorded.

3. Questionnaires were completed by all experimental participants before, during, and at the end of treatment. These questionnaires assessed pretreatment expectancies and motivation as well as daily sleep patterns and posttreatment satisfaction. Follow-up questionnaires assessed self-reported changes in snoring level from post-treatment.

RESULTS

Audiotapes

The effects of treatment on two primary dependent variables, *mean peak snoring amplitude* and *frequency of above criterion responses* were analyzed. Because the results of the latter measure were consistent with the former, data analyses will be presented only on mean peak snoring amplitude. Mean peak amplitude was computed by the following procedure. Every 9 min, a 1-min epoch of polygraph record was sampled. The amplitude of the loudest response in that interval was assessed by calculating a ratio of the pen deflections produced by the response/calibration signal. For each 3-hour tape, 20 values were generated in this fashion and averaged, yielding 1 amplitude score per night. Figure 1 represents the mean peak amplitude for groups plotted over trials.

When these data were analyzed by means of a change score (post-pre) ANOVA, the effect of

³Details are available upon request.

Fig. 1. Mean peak snoring amplitude for three groups before, during, and after treatment.

groups appeared to be marginally significant, $F = 3.29$, $p = .058$. Planned orthogonal comparisons indicated that although the two treatment groups were not significantly different from each other, the combined effect of the two treatments (CA + SC) was significantly different from the control (WL) group, $F = 5.98$, $p = .024$.

To include the effects of the follow-up assessment, it was necessary to perform a separate repeated measures ANOVA on the two treatment groups alone. Again, the factor of treatment condition was not significant, $F = 1.04317$, $p > .10$. However, the linear component of the "trials" factor was highly significant ($F = 8.307$, $p = .006$), and indicated a substantial decrease in the amplitude of response from pretest to follow-up.

Contingent-Awakening Group Shaping Results

Data collected on the CA unit threshold adjustment can best be illustrated by reference to Figure 2. The figure shows the number of responses recorded during the course of treatment

for two representative participants. Inspection of this figure indicates the continuous learning curve characteristic of most participants' progress through the CA program.

Self-report Data

Questionnaires were completed by all experimental participants and consisted of 7-point rating scales and additional open-ended questions. Pretreatment questionnaire responses indicate a high degree of motivation and confidence in both treatments. Posttreatment self-reports reveal a high level of satisfaction with the results of treatment. Follow-up questionnaires corroborated the continuing reduction in snoring levels after treatment termination. A final interesting finding was the apparent lack of recall of the number of awakenings by members of the CA group.

DISCUSSION

This study was designed to investigate the efficacy of two experimental programs for the suppression of noxious snoring. The results indicate that both treatments produced a substantial decrease in snoring amplitude and frequency. A possible problem in the interpretation of these results is the absence of a pure attention-placebo control group. Therefore, it cannot be concluded that the results were not, at least in some part, attributable to the influence of expectancy variables. This is less likely in this case, however, because the participants in the present study displayed a chronic history of loud snoring (mean duration = 11 yr), and previous research (Boulware, 1966; Robin, 1968) has emphasized the resistance of an ingrained snoring habit to most nonspecific approaches to modification.

Both treatment groups also showed a continued decline in snoring during the follow-up period. This finding suggests that a skill has been acquired or a new habit pattern strengthened. The slight increase in snoring observed in the WL group may be attributed to several factors: habituation to the reactivity of recording, ran-

Fig. 2. Changes in activation threshold (shaping) for two participants over twelve days of contingent-awakening treatment.

dom variability in snoring levels, or some reactive effect of anticipating treatment.

An additional methodological limitation of the present study was the absence of a fourth data point from the WL control group at the time the two experimental groups received the 1-month follow-up assessment. These additional data would probably have strengthened the results, as the two experimental groups appeared to be showing further improvement at that time.

Although visual inspection of the data suggests superiority of the CA treatment over the SC treatment, this difference was not statistically significant. Perhaps the small group size, high intrasubject variability of response, and possible ceiling effects prevented the detection of significant differences between treatments.

To the extent that snoring is a prevalent behavioral problem for which there is currently no experimentally validated treatment, this study represents an important new application of behavior modification. The study also raises inter-

esting basic research questions regarding the nature of sleep learning occurring during sleep. Despite the apparent lack of recall by subjects of the tone activation and subsequent lever-press response, conditioning nonetheless appeared effective.

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